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WAR SURGERY

THE PRESIDENT'S ADDRESS OPENING THE FOURTH CONGRESS OF THE INTERNATIONAL SOCIETY OF SURGERY

BY PROF. DR. ANTOINE DE PAGE

OF BRUSSELS

AT this opening of the Fourth Congress of the International Surgical Society, I am sure that your President may be permitted to delay the beginning of the scientific discussions for a short time, to salute the great American Nation in the name of all the members of the Congress.

The first three meetings of the International Surgical Society took place in Belgium: we gave the preference to a neutral country, so as to clearly define the scientific and, at the same time, fraternal character of our Association.

It is not necessary for me to tell you that it is the privilege of our little Belgium to offer a meeting place to the learned men of all nationalities, covered by Europe herself with the shield of peace and liberty.

How did we decide without hesitation to accept the cordial invitation of our American colleagues?

Such an important decision was not justified merely by the deep esteem we feel for your great surgeons, or by the most legitimate curiosity; it was influenced chiefly by the certainty that we should all receive a welcome prompted by the most noble sentiments of scientific fellowship. Belgium asserts her pacific tendencies by her political neutrality and by her industries, which can only prosper in times of peace; mighty America disposes otherwise: she favors the treaties by arbitration which are the triumph of right over might, she organizes her universities and her scientific institutions, which assure more and more the victory of intellect over force and chance.

The International Surgical Society in quitting the neutral soil of Belgium, and in choosing New York as the seat of this meeting, shows the high esteem in which it holds our American colleagues, and at the same time the confidence it feels in the final triumph of the ideas

of peace and civilization, that the United States personify throughout the whole world.

We surgeons necessarily represent by our profession itself a mute and constant protest against the evils of war, by organizing help for the wounded, and working during the periods of peace, to anticipate all the horrors of the battle-field, so as to be ready and waiting with our help.

We impress upon all, that war is the greatest of scourges. When we give an account of battles, we do not enlarge upon the heroic side, although we are fully sensible of its grandeur, but rather discuss the consequences of war, we produce statistics, which present a formidable list of wounded, killed, mourning, sufferings and horrible mutilations.

The surgery of war owes much to America; in 1861 you were surprised, so to say, by the Civil War; nothing had been prepared to sustain the gigantic struggle into which you were drawn; your medical service, as well as your army, was, so to say, in its infancy; then improvised soldiers started up throughout the length and breadth of your territory, and help for the wounded, organized by countless numbers of committees and of associations which acted in unison, thanks to the initiative of a man, that America may rank amongst her great citizens, Pastor Henry Bellows.

The Sanitary Commission was acknowledged and established by President Lincoln under the name "Commission of Enquiry and Information for all that concerns the sanitary interest of the Union Armies."[1]

The writers of the history of the War of Secession have described in glowing colors the noble part this Commission played in the course of events; it was, writes an eminent author, "the great artery, which carried the love of the American people to the army."[2]

Gentlemen, if I here refresh the glorious, but at the same time painful memory of these heroic times, it is that since fifty years new duties have arisen, with which it is of importance that the surgeons of all countries should reckon. The time has passed when the art of war was but a manifestation of exalted personal courage; the art of war has called science to its help, and the response has been a fearful perfecting of the means of destruction. At the same time in

[1] The United States Sanitary Commission.

[2] *La médecine militaire en France et aux États-Unis,* par W. Laboulaye, membre de l'Institut, 1869.

the countries of Europe the general military service is becoming universal, in such a way, that a number of combatants unparalleled before, are to be foreseen in future wars. We should therefore be employed in perfecting our sanitary organizations: the technicians of war have been able to proportion the thickness of the armor-plate to the penetrating power of the projectiles; they have multiplied the means of defense in the same degree that the force of the engines of destruction has increased.

With us rests the task of developing the organization of our war surgery, so that it may remain on a level with the sad needs of our times. American surgery here again has furnished us with important illustration.

Keen's Surgical Encyclopædia contains admirable studies, for which we are indebted to our eminent colleagues Borden and O'Reilly, who have faced the problem with perfect capability and experienced reasoning, to whom all homage is due.

These authors have rightly laid stress on the weight of responsibility which the practice of military surgery entails, and on a previous and altogether thorough medical organization. The precautions that would have sufficed formerly, are inadequate at the present day.

I must be permitted to draw the attention of this chosen public to the existing state of affairs; that the international understanding should be reinforced more and more by the organization of help for the victims of war, is a thing greatly to be desired.

Without doubt this understanding already exists; the Red Cross is the most striking illustration of it; and at the time of the last Balkan War, we saw ambulances which had come from all countries, repair to the seat of war.

When I arrived at Constantinople in November, 1912, with the Belgian ambulance, I already found the American ambulance installed and in full working order, under the direction of your eminent countryman, Doctor Ford.

This international fraternization is without doubt an encouraging sight; this humane impulse cannot be praised sufficiently.

To augment the number of these foreign interventions is much to be desired, not, however, exempting Governments and Administrations from local organizations of help.

It is the insufficiency of the latter that must be remedied; because we must, alas! think of future wars, let us remember that our responsibility as surgeons increases with the dangers of the present time.

The Balkan War has only emphasized the lesson taught by the

Manchurian War: the fate of the wounded depends more than all on the aid which is given in the front of the battle, for as long as the engagement lasts, the exposed ground is inaccessible for the ambulance men, of whom more than one has sacrificed his life in spite of all precautions taken; thus hours pass, during which the men remain without help.

Schaefer [3] has drawn a heart-rending picture of this deplorable state of things. Haga [4] acknowledges that it is no longer possible for the ambulance men to circulate on the battle-field, exposed to the hail of the shrapnels. What is to be done?

The following is without doubt the solution: each of the combatants must carry with him, side by side with his cartridges, the objects necessary for a first dressing. This solution has already been accepted and taken into use in different countries; at the most an improvement on this idea could be realized, by adopting a model of uniform packet for first aid; but the experience of the late wars has only proved too clearly that, before all, the sanitary education of the soldier must be improved.

He must fully realize the dangers of infection, by earth, dust and water; of what use is a disinfected compress, if it is soaked in polluted water?

A soldier must also possess knowledge of certain simple facts, for example, he should be aware, that in case of a wound in the abdomen, it is better to rest motionless, even if for hours, than to walk as far as a station.

The military instruction of a soldier in future will not be complete unless it comprises an acquaintance with the necessary measures to take for his personal safety, and especially the elementary rules of asepsis and antisepsis. The making general these instructions will result in a great saving of human life, I think.

Do not let us even leave the bringing of first aid to the wounded for the ambulance men, as thus, it may often arrive too late.

May I be allowed again to call your attention to a certain point?

If it is true that immediate help is the most efficacious on the battle-field, it must be considered that this help should be limited by precautionary measures, the stations at the front, those temporary erections which change place as the troops change, and cannot be provided with the necessary implements as hospitals, are only stop-

[3] Schaefer: *Archiv für klinische Chirurgie*, 1906, p. 915.
[4] Haga: *Kriegschirurgische Erfahrungen*, 1897.

ping places, where the sick and wounded are sorted out. Unfortunately they are not always made use of in this way: during the Balkan War the Turkish army doctors and others tried to extract the bullets and amputated in the ambulance at the front, and we were able to certify that on the arrival of the wounded at the hospitals of the town, the greater part of these interventions had produced deep-seated suppuration.

In the hospitals of the second line, which never change place whatever happens, the operations could be performed that were judged indispensable.

There experienced surgeons should be placed, who would have to decide the serious questions, and the most pressing and grave interventions would be decided on and carried out in these hospitals of the second line, where the wounded could be taken whose condition did not permit of a long transport.

Civil consulting surgeons should also be attached on regular duty; from every point of view this addition seems to be desirable, the presence of these civil surgeons at the hospitals would give them a neutral character, which they have not at present. The capability of these consulting surgeons would assure the utmost caution being used at the critical moment, when the fate of the wounded is in the balance; in short, these tried surgeons would oppose the performance of all operations, of which they did not clearly see the urgency.

We all know that a man surprised by a traumatism can oppose less resistance to a general shock, than another who has had the time to prepare and arm his organism.

The wounded leave the battle-field discouraged, worn out, and join in general the number of " bad cases "; therefore still more reason to be careful.

Respect for human life should be our only guide. The finest operation is not always the most well directed, neither the battle-field nor the surgical clinic allow of experiments on human beings.

The discharge stations should keep up their character, therefore the addition of experienced civil surgeons appears advisable. During the last wars, a fact which filled all the surgeons with astonishment, is the comparative harmlessness of the modern gun; of it has been said that it is a " humane weapon," as if these two words would not swear at finding themselves together. But for a fact, I have seen, and others have also seen, bullets which had pierced the arm or the leg sometimes throughout their whole length, and others the abdomen

or the breast or even the back of the brain without producing infection or any serious consequences.

The fact was so generally remarked upon, that the military authorities took up the matter; it is not uninteresting to notice this, just at a time when the effects of the cannon have become more deadly than ever.

Surely we surgeons will not reproach the modern gun for not killing his man with every shot, what we do desire is to reduce the so-called " efficacy of the shrapnels," it is too horrible.

At a meeting of the Imperial Surgical Society at Constantinople, December, 1912, just at the time when we could hear the thunder of the cannons of Tchatalja every day, we expressed the fervent wish, that the use of the shrapnels might be abolished on the same grounds as the explosive bullets.

To military men this wish may appear naive, I do not deny it, but at the same time let me tell you, that I am not in any way ashamed of it.

It seems to me that here, so far away from the lands divided by a deadly animosity, you will appreciate this wish as a protestation against the cruelty of war. Yes, I boldly state, that we who are brought into such close contact with the dreadful miseries of this poor human race, find it more and more difficult to understand, why men do not employ their reasoning powers to a good end by ceasing this destruction of one another. We hope soon to see the " United States of Europe " in friendly intercourse with the " United States of America," and if we salute the eminent men present at this Congress with profound respect, we reserve our deepest admiration for those amongst them, who, following in the footprints of Franklin, Lincoln, Roosevelt and Carnegie, work to assure universal peace.

AMPUTATIONS*

By Prof. Oskar Witzel, M.D.
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The removal of limbs has undergone a great change in the last decades. During this period amputation has become an art which can no longer be considered a beginner's task. In emergency cases every physician must be able to perform this operation at once, if necessary to save life. But otherwise it demands the highest surgical skill, both in determining the indication and in the proper execution.

Amputation has become rare in the surgery of peace. By all possible means its use is being reduced also in war. In the great traumatic epidemics even to-day more limbs must be sacrificed, it is true, to save more lives under the stress of circumstances which it is our constant aim to alleviate. For in time of war it is our highest duty to procure as far as possible the help available in time of peace for those who stake their health, their life, for the welfare of the nation.

The progress of surgery makes it possible under the protection of a simplified and certain antisepsis and asepsis, to wait longer in treating lesions, in order to see what is in reality traumatically destroyed, and what may unexpectedly recover. Crushed parts which infection formerly made a menace to life, can now be preserved. What Lister emphasized as the guiding principle in the treatment for wounds: to let alone—has been disregarded, almost forgotten in the overactivity of our antiseptic era, very much to the disadvantage of the wounded. Von Bergmann rendered a service of incomparable value in introducing simple measures for open fractures in war and insisting with all earnestness on their use also in time of peace. Extremities whose removal seemed hitherto inevitable in consequence of vascular lesions are very often successfully preserved in time of peace by means of operations on the vessels, suture, anastomosis and transplantation. The benefits of these advances have already been extended by practiced hands to the wounded in military hospitals. The gradually increasing occlusion of the vessels, such as threatens the extremities with gangrene in arteriosclerosis, can be combated through anastomosis of the large arteries and veins. In this way the future derangement of vitality becomes a rarer indication for the removal of a limb.

* Read before the International Society of Surgery, April 13, 1914. Translated from the German of the author by Dr. Oswald Joerg.

The sequelæ of acute inflammations and of chronic inflammatory changes put before us the question whether to amputate or not, irrespective of whether the fault lies with the patients or their physicians. Not only as a prophylactic in the very beginning, but also as a treatment at the height of the inflammation, the measures recommended by Bier, especially for the extremities, achieve remarkable results in removing the necessity for a mutilation. If there is any suspicion of the wounds becoming infected (they are all, briefly speaking, affected at least by an "infectio minima insensibilis") we may avert phlegmonous processes through hyperæmia induced by bandaging (Bier's hyperæmia). If they do appear, nevertheless, incisions which preserve the tissues are used together with the hyperæmia in order to prevent sequelæ and general health-endangering conditions which even to-day may ultimately require amputation. In the further development of surgical interference which has made unnecessary the removal of congenital and gradually forming *deformities,* we have learned, if contusions or inflammations were followed by strongly disturbing sequelæ, to perform operations on the bones, joints, musculotendinous apparatus and on the nerves which restore them to painless use.

The indication to amputate on account of the *formation of tumors* could be modified by resections in cases of benign tumors; also in the case of myelogenous sarcoma, plastic operations and transplantations, are aiming to replace completely the removed parts in regard to form and use. By means of radiotherapy, the powerful assistant which has come to the aid of operative surgery, we hope to be able to limit mutilation also in the case of tumors which until now, even in the early stages, offered a prospect of cure only by immediate amputation. In the case of the extremities this holds good especially for periosteal sarcoma.

The right to the judgment that a limb cannot be saved, therefore, presupposes an exceptional familiarity with the progress of our science. An equally exceptional ability is required for the execution of the amputation.

The necessity to draw upon such knowledge and ability may come to the non-operating general practitioner at any hour. He must, therefore, know the modern demands of amputation, especially with regard to the changes in the establishment of the indication. In full appreciation of the minutiæ through which the very best can be obtained in clinics, we must endeavor to simplify our proceedings to the utmost with regard to the execution and the necessary remedies. The dictum of Boarhave: *simplex sigillum veri,* is peculiarly true in practical medicine and in "emergency amputation" in peace and in war; but it is also true

in the case of "interference which is optional as regards the time of execution."

The execution is never so urgent that the demand to raise the capacity of resistance against the effect of operation could not be fulfilled. Where the date of the operation is optional, neglect of careful preparation for the purpose of increasing the strength of the patient is a gross technical error. This preparation may take days, even weeks. Here, in advance of the surgeon's skill, the physician's foresight is to come into play, especially in regulating and strengthening the heart and cleaning the air passages by prescribing both medicines and systematic breathing exercises which later on also afford the best protection against thromboembolism. In the case of emergency operations, the measures for strengthening the general health coincide for a short time with the technical preparations for the surgical interference. When treating a trauma, before the patient goes to the operating table, the heart excitants, ether and camphor, are given, with the great quieter, morphine. Where it can be done, the quantity of blood is increased by salt infusion —provided there is absolute safety against further bleeding. This may be rendered more valuable by oxygen inhalation. Above all, the bloodless need protection against loss of heat. Provision must be made for warming the operating table.

Certainly, also, the interference in itself is an injury. Possible developments that may arise (during the operation itself) must be so carefully considered in advance that death on the table during operation may be excluded, and where the case is known to be a hopeless one, the operation should never be attempted.

A mortality, caused from the amputation itself, must be absolutely excluded, even when section occurs high up near the trunk! The patient should never lose his life during operation through impairment of the circulation and the nervous functions. He must be guarded against further danger of life after the operation. To accomplish this there must be a positive arrest of hemorrhage and an absence or at least a minimum of pain in the care of the wound, and perfect technic of the operative procedure. But nowadays even more important than conserving life and bringing about a final cure is the accomplishment of a condition whereby the usefulness of the stump, as far as its strength and mobility are concerned, is attained.

Great progress in the direction of arresting hemorrhage was made by Esmarch and his achievements are all the more notable because of the simplicity of his method and the surety of its outcome. Even on the battlefield a surgeon, or in case of necessity, an experienced assistant,

can exclude the blood from the particular member about to be amputated by applying elastic bandages and elevating the limb.

The fastening of the ligating tube requires special means in cases of high amputations and for exarticulation at the hip- and shoulder-joints. The tube applied in figure-of-8 turns can be fastened by suture and secured against slipping off by means of large needles and stick-pins. Sometimes the external iliac artery or subclavian is to be ligated; even permanently, as long as it does not endanger the vitality of the flap well provided for by collateral vessels; otherwise temporarily with a loop which will be taken off as soon as the large vessels in the turned-over flaps are cared for. In Momburg's compression of the aorta by an elastic bandage around the abdomen, which had a forerunner in Esmarch's somewhat more complicated compression of the aorta, an excellent method of prophylactic hæmostasis at the root of the thigh and of the pelvis is also given to military surgery.

It must be always emphasized that in cases of amputation the prevention of pain is an essential factor. The exclusion of the psychic factor through a general narcosis which may be brought on as early as the night preceding the operation, is a command of humanity which is to be fulfilled whenever possible. To the one patient camphor and morphine are administered before the emergency operation, to the other veronal or laminal the evening previous in order to induce a thorough night's rest. An hour before beginning the narcosis there should be given a clysma with alcohol and tea and a dose of morphine as a result of which the patient will arrive half asleep in the operating room. Afterward, for the real narcosis, *ether,* not chloroform, is to be used,—for wounded patients suffering from severe hemorrhage or shock only a minimal quantity, applied in the right way, is required. There can be no doubt in the mind of anyone who is familiar with our combined ether-drop narcosis as to its reviving effect in cases of collapse.

Other methods of anæsthesia are employed only in very special instances, *e.g., Bier's lumbar anæsthesia* for amputation of the leg because of senile gangrene. Here, too, general anæsthesia has been used as long as no complication with diabetes is present which contra-indicates the cerebral narcosis on account of the danger of coma. But the use of anæsthetics in the spinal cord, though possible for the removal of the leg, can as yet not be considered for the amputation of the arm. For it is accompanied, when applied to a very high point, with a great degree of danger so that it must not be attempted unless no other remedies exist. A method very suitable for major operations on the upper and lower extremities is that of Braun; it can be perfectly performed in the brachial

plexus for the arm, for the leg with injections into the sciatic, crural, obturator and the cutaneous branches of the femoral nerve. Harmless by itself, in connection with remedies diminishing the capacities of feeling and thinking, this method may find its place where the cerebral narcosis is impossible. Hackenbruch has shown that for the high amputation of the leg, even for Chopart's complicated operation, the injection all around the nerve may cause perfect painlessness. His method, however, cannot well be used in major operation. It is excellent for minor operations in the realm of general practice, especially because it does not largely take anatomy into account.

To encourage the ***healing process of wounds*** the older surgery preferred the most simple methods of removal, *i.e.*, in which smooth surfaces are formed. With open treatment, often uninterrupted cure would follow. Even to-day preference is given to the circular section for amputation in cases when the parts are greatly infected. Even to-day open treatment should be used, provided it is important to avoid any retention of secretion. Besides, the amputating surgeon must have full mastery of an asepsis which forces the quick healing *per primam intentionem.* He must work with an antisepsis which shortens the process even where the operation is to be performed in infected parts.

The decision whether the removal—even with peripheral infection—falls into entirely clean parts or not, is of first importance for the further procedure and the success. Usually it is easy. But often it is, even with experienced surgeons, not to be accomplished without difficulty. If we remove congenital superfluous parts or limited malignant tumors, we must be sure of the cleanliness in the sphere of operation. On the other hand, we are also sure in many cases to have to force our way through infectious tissue, through lymph passages carrying germs, even through larger inflammatory foci. Consideration before decision, care for the success, must rule our action in these different types of cases. Experience must tell us whether we have to sacrifice more to attain uninterrupted aseptic care, or whether we have to proceed antiseptically to save more, as well in the preparatory treatment of the parts, as in abundant evacuation of secretion, as in the after-treatment. At the same time we have to come to the decision in regard to the height and the mode of the amputation.

Where age is to be a determining factor in deciding the type of the operation we must remember that in young tissues we can count upon good plasticity for the union, whereas old tissues demand simple junction; if the question of the blood supply is to be considered, disturbances in its quality, especially diabetes, are to be considered in planning the

technic; the chief condition for complicated operations is to have the entire region in an aseptic condition. An infection that could not be removed before demands simple procedures.

The problem of the safe protection of wounds is much greater in cases of amputation than is generally believed. The resulting wound becomes sinuous, as hardly any other one, in consequence of the irregular muscular and tendinous retractions, even when the plain circular and oblique section is used. We must always be watchful of "dead spaces." We shall hardly learn how, by any calculation as to the different retraction, to accomplish the separation so that a smooth wound will be the outcome. In the case of some amputations we know that certain positions of the joint, above and below, assist in securing a smooth wound. The rest must be done with buried sutures which unite the separated layers throughout the entire extent of the wound. Even then an uninterrupted healing cannot be expected, unless another postulate is fulfilled, namely, that the tissue layers enclosed in the healing process have not lost their vitality.

The separation of the soft parts must be done smoothly with a sharp knife. The use of scissors still crushing is to be avoided as much as possible. The soft parts are extended in the following manner: The upper half grasped by the hand as far back as possible is stretched toward the trunk, while the lower half is being pulled with the aid of an assistant. With sharp-pointed hooks we lift off the flaps, with a toothed forceps we draw down the nerves and vessels to be removed, and grasp muscles, tendons, and the edges of the skin for reunion. Every contusion is avoided, for it leaves the parts, if not directly crushed, deranged in their circulation and prone to infection. Even during the short interference of a simple operation, trifling drying and cooling are to be avoided, especially if the circulation is artificially shut off, since they tend to cause congestion and secretion from the surface of the wound. If we do not pay attention to this precaution we damage the most superficial tissue layer, as was the former rule, when applying antiseptic, corrosive remedies. With the object of preserving the tissues we omit the antiseptic, chemically necrolizing substances even where we must pass wholly or partially through infected tissues.

Only in tying a vessel and for buried sutures we are compelled to bring an antiseptic agent into the wound. Heretofore we have not possessed a thread material which fulfils its mechanical object and is aseptic, free from antiseptic agents. The effort so often tried to use only sterile threads has always resulted in failure, in so far as the threads introduced as foreign bodies cause irritation that in turn de-

velops germs which are present in each wound and are carried into the circulation. Threads antiseptically prepared of great durability are selected, and chloride of mercury silk prepared in accordance with Kocher's prescription is immersed in wounds which are able to heal *per primam*. It disappears, " substituted " by a very slowly advancing dissolution. In infected wounds we use catgut which is quickly absorbed, so as to avoid the formation of thread fistulas with the healing of the tamponed cavity.

Besides careful ligation of the large vascular trunks and of the visible branches, the other measures against hemorrhage, applied immediately after operation and also subsequently, are of great importance for the healing of the wound. Esmarch's artificial anæmia during the operation is for this positively an aggravation. An increased number of ligatures beyond what is necessary in another wound of the same size must be applied, if we first loosen the constriction at the wound still open, and then ligate the vessels. We cannot avoid this if we operate upon tissues the vitality of which is reduced by arteriosclerosis or contusion. Not to be obliged to bury too much thread material, we make sufficient use of torsion, the technic of which seems to be lost, at least for the text-books. It is done in the following manner: the spouting end is pulled out, then held across with a second pincette, when the former closes and pulls off the point by turning. Where we operate in really vital parts, we apply a row of sutures in the depth, then unite the skin and then loosen the constriction. To check the profuse hemorrhage arising from the blood shooting into the sewed-up stump, we make long-continued manual pressure.

In order to be assured of an uninterrupted recovery, the operation itself must be such as may be characterized by the three words, " gentle, moist, warm." Again the vessels must be well closed, which prevents the subsequent extravasation of blood and lymph and with this the collection of nourishing media for germs in void spaces.

The securing of primary union is hardly of such importance for the future function in any other wound as it is in the case of an amputation, and consequently we must be conversant with seeming trifles which, in this regard, have importance. Drainage, even when short tubes are used, is to be avoided, whenever possible; for it renders the desired fine cicatricial line broader or causes a button-hole scar. At any rate the drain ought to be removed in the first days. But each change of dressing considerably disturbs the rest which is very necessary for the amputated stump.

A very essential completion of asepsis in the amputation wound is

offered by the mode of dressing devised by me which I have called a wound-pull-dressing." The pull-dressing of adhesive plaster was first employed by me for amputations done on account of senile gangrene. But it offers extraordinary advantages for all types of amputation. With a broad adhesive strip applied over the wound dressing and reaching far up, it relaxes the sutures, if the wound is entirely closed, compresses slightly the cap formed out of soft parts, and pulls it off from the bone and prevents, if the wound is left open, the strong retraction of the flaps of the cuffs. This dressing brings, in a very agreeable way, rest to the stump and safety from agonizing spasms, without a weight upon and bindings around it.

The careful protection of the wound prevents either circumscribed or far-reaching infection. Through many well-considered and executed particular measures, we owe the steady decrease of the former " classical " mortality.

Even on the battlefield where the time of the attending surgeon is limited, the fulfilment of the operative task has to be done within the bounds of the foregoing remarks. The risk to life through operation must be excluded *per se*. One thing, however, is to be demanded, that the mutilated must be saved from the terrible torture of amputation neuralgia. Also for this it needs but simple measures.

More than 25 years ago, Billroth requested his colleagues to communicate their experiences relative to the cure of this horrible malady which, even in the modern text-books, is frequently considered to be a result of the formation of " amputation neuromas." On the basis of examination of old amputation stumps, both in preparations as well as in living bodies, I was able then to show that the amputation neuroma, the terminal intumescence of the bisected nerve, is the result of an abortive effort of nature to regenerate the lost part towards the periphery. This attempt (of nature), which happens rather frequently, leads to the rolling up of the neoplasm in the form of roundish masses. Provided these knobs were always a sign of the amputation neuralgia, we ought to cease operating. It was shown that with stumps of patients suffering from neuralgia the cause is not the terminal intumescence, but the fixation of the nerve to the secondarily formed scar and of the latter one to the bone. At first very sensitive to pressure, as may be easily understood, the stump gradually becomes the seat of the neuralgia through irritation of the " glued together " nerve-trunks through flexion and extension. It is well known, that the neuralgia ascends the nerve-trunks—as anatomical foundation a perineuritis nodosa is found which also fixes the trunk further up and prevents it from making sufficient

excursion in its sheath, which is a physiological necessity. This condition is not unlike the difficulty of redress which finally becomes an impossibility, as even sections and resections at the origin of the nerves in the spinal cord remain of no avail. Simple and sure was the prophylaxis which we recommended even at that time! It does not require the neurincampsis later developed by Bardenheuer, nor the cuneiform excision with subsequent very fine suture of the perineurium according to Ritter. These are methods which are at least difficult with thinner trunks and cannot at all be performed on the battlefield. We taught to save the nerve end from being fixed, for this is the cause of the neuralgias, by strongly drawing forth—that can easily be done with most of the trunks up to 4 or even 8 cm.—and by smooth separation by means of a sharp cut with the knife. We encourage our pupils to execute this manœuvre upon the nerves always prior to division of the vessels. The end slips far back into the layer of connective tissue and later on glides painlessly with the " neurom " to and fro. This excision must be made the more carefully and higher up according to the possibility of a secondary healing of the wound.

But the demands of modern times for the success of amputations are not limited to the exclusion of danger to life, the achievement of uninterrupted healing of the wound and avoidance of the coarse disturbance of the amputation neuralgia. We have to *produce stumps of the highest usefulness*. We already possess sure and, fortunately, very simple methods to facilitate accomplishments which we formerly believed to be absolutely unattainable.

Provided we do not desire to have the stump hang useless, swinging in its capsule, and if we want it to serve actively to the motion even when directly loaded, it must be, in the first place, painless, free from pain when the soft parts are shifted or pulled at, or pressed against the end of the bone. But the stumps of the diaphyseal amputations made in accordance with former methods were rarely of this kind, and this was even more the case with the deformed stumps arising from exarticulations or amputations in the epiphysis. To bring about painlessness in the latter group, uninterrupted healing *per primam intentionem* was the necessary supposition. Stumps of the articular extremities healed by suppuration and with broad adherent scar.

The excellent investigations of Bier have shown under what circumstances a stump may be entirely painless and remain so. The conception of Bier in regard to the cause and nature of the sensibility is indeed still under dispute.

On the stump formed after the method of Pirogoff the patient, after

the cap of the heel is united with the leg, walks painlessly, resting directly upon it. It must be especially emphasized that the same is true with amputations according to Gritti. In both cases a skin heretofore little accustomed to pressure comes under heavy weight and is transformed into callosity. Bier, through a complicated procedure, leaving skin and the flap of the soft parts in connection, formed a similar covering for the diaphyseal stump. This became directly capable of bearing like the stumps of Pirogoff. With like success, but in a simple way, he formed the great flap of skin and the periosteal covering of the bone, both isolated, taking care that the weight did not fall upon the line of suture. Thus another surface scar was situated between the periosteal covering of the bone and the skin. These stumps, too, remained painless, if weight was put upon them. The undisturbed physiological connection between the flaps of the soft parts and the bone, as was the case with both Pirogoff and Gritti, is not entirely necessary, although they do lessen the possibility of the shifting of both layers against one another. But now it appeared that the same could be effected by a soft cover, derived from an adjacent tendon according to Wilms or from transplanted fascia according to Ritter. At last it was found that no covering is necessary at all, and that the stump remains painless, provided, as Bunge suggests, a part of the bone marrow is emptied with a spoon and at the same time a periosteal cuff at end of bone is removed.

Our conception of the advantage gained uniformly by all these procedures, from Bier down to Bunge, is that a swelling of the marrow freed from pressure, as must occur by vascular pressure from inside, is prevented, and that the nerve ends of the cover of the soft parts are not fixed upon an osseous foundation. If the mushroom-like outgrowth is not prevented, a rough proliferation by ossification ensues which includes the neighboring nerve-fibres. Even in primary union we have the nerve fixation which, if it concerns the trunks, leads to neuralgia and, if as in this case it concerns the branches only, to the simple sensitiveness of the stump. Thus, the painlessness of the stumps after exarticulation and after removal in the epiphysis is explained. A swelling of the marrow does not here take place.

Amputating in accordance with the methods of Pirogoff and Gritti, we obtain in consequence of the effect of the cover a stump capable of carrying weight, even if the sawing is not done, as is customary, in the epiphyses, but in the diaphyses. Instead of Gritti's operation we shall occasionally execute the original plastic one according to Bier, by uniting the anterior surface of the head of tibia with the lower end of the femur, according to Sjabanejeff. We shall make the cover in

accordance with Wilms, using the tendo Achilles or the tendon of the triceps humeri; on other occasions the diaphyseal stump is to be treated under ordinary circumstances, certainly always by the physician in the field, after Bunge's direction. With amputations in the epiphyses it needs no cover-formation, scraping with a spoon or periosteum-removal; but here, like at the exarticulations, an improvement through removal of corners and edges may be made.

The last fear of the nerve-fixation may be removed, provided—as Hirsch suggests—we execute in all different proceedings early and methodically the shifting of the parts against each other, beginning by *massage à friction* towards the periphery, afterwards by tread-exercises or by direct loading of the stump in a provisional self-made wooden leg (Bier). It is astonishing to see, how well such manipulations for securing the mobility of the cover of the soft parts can be tolerated even after two weeks, *prima intentio* just accomplished, and how after four weeks the stump can be used as a firm support, and how a patient with both legs amputated walks around upon the stumps only protected by wrapping.

It may be mentioned that Hirsch's treatment of exercise and massage is capable of rendering stumps painless, even though they have been obtained by other methods and are already becoming sensitive, and that it works excellently after the reamputation which became necessary on account of great tenderness.

It is gratifying to note that from a complicated method we have been able to finally devise a simple one, applicable everywhere, and which affords a painless stump.

But this is not enough. A lever thus obtained tolerates, according to our wishes, direct pressure and pull in the artificial limb. It ought to move the latter as well as possible as a lever working as a whole; the most important isolated movements of the artificial limb—this is the last request—might be executed actively, dependent from the will-power in using the musculotendinous apparatus terminating in the stump. The prothesis shall be " revived " by the stump. To secure the first object it is necessary to equilibrate the lever-effect, and that is mostly done after simple calculation in uniting by suture or insertion the muscles and tendons.

Added attention given to the function of the stump has shown that disturbances were brought about through irregularity of muscle-effects, stronger on one side, producing a preponderance in the sense of motion, extension and rotation. In short stumps of the legs and thighs, but also of the fore and upper arms, the resultant positions may be an impedi-

ment even for the application of the prothesis. The contractures developed this way have been combated by tenotomies; thus, in a crude way, by disconnection of power in the lever of the stump. This is evidently wrong. On the contrary we are now striving from the beginning to avoid the antagonistic disturbance, the deficiency of a whole kind of movement, leaving sinews and muscles longer in the stump and fixing them by suture to the neighboring ones near the bone. Of especial value through its simplicity is the procedure which unites the muscles and tendons of one side, sewed up with each other and combined into a well working mechanical totality, across the stump with its antagonists treated similarly.

In obtaining such an equilibration much remains to be done with respect to the physiology of the stump. What cannot be satisfactorily achieved in the first way, must be obtained secondarily by orthopædic operations.

Finally, we must consider the utilization of single parts of the musculotendinous apparatus for the intended transmission of movements upon the prothesis. For the leg it suffices that the stump may be supported directly and painlessly, and that it acts as a lever in good order, but for the hand we must ask and achieve more.

Vanghetti proposed to use tendons to form rings through which strings may be framed which shall transfer movements to the prothesis. This procedure is doubtless valuable. We would even now adopt it in cases of reamputation on forearm stumps, whenever such opportunity appears. Unfortunately, a longer time is apt to elapse before opportunity for such an amputation of the forearm is given. It follows that in cases of amputation at the wrist-joint the tendons of the extensor digitorum communis, of the extensor pollicis major and minor, may be united to form a single loop; the same may be done on the flexor surface. There results on the dorsal and volar side one ring for the thumb, and one for the four fingers in the skin sac. It need not be specified here, just how, after *prima intentio* has resulted, such loops based upon the principle of the ear-hole are to be made in a plastic way.

Merely worthy of mention is the attempt to produce actively movable levers out of periosteal fragments of bone, retained at tendinous insertions, as, for example, the two-step transplantation of a finger; for instance, a stiffened ring-finger of one hand as compensation for the thumb of the other, as well as the two-step transplantation of a piece of rib, originally enveloped *in loco* with skin, to the place of a thumb, an effort in which we have been successful.

AMPUTATION OF THE HAND*

By Dr. P. von Kuzmik
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The surgical treatment of amputations and exarticulations in recent years has been as conservative as possible. The practically perfect application of *asepsis* and *antisepsis,* the extraordinary results achieved by the newest curative methods, the improvement in and the more thorough utilization of the methods of investigation in every respect have naturally strengthened the conservative point of view which is so important for the patient. This attitude is especially important with regard to the preservation of the upper extremities, the hand and the fingers, the loss of which, despite great technical progress, cannot yet be replaced satisfactorily.

While an able surgeon can to-day so remove the lower extremity that the patient shortly after the operation may, by means of an artificial limb, regain his entire ability to work and be able to conceal his defect completely from the layman, the loss of a hand, the fingers and even of individual joints of a finger, materially reduces the ability to work, and the deformity due to the mutilation can hardly or not at all be concealed. The fault for this regrettable condition does not lie in the surgical technic, but in the method of replacing the defects caused by amputation, as the mechanics of to-day can hardly boast better and more perfect results than at the beginning of the sixteenth century with its replacement of the right arm of *Goetz von Berlichingen.* Our aim should, therefore, be to save the hand and its smallest parts by exercising great patience and care and by the use of all the scientific means at our disposal.

Limited mobility, ability to use the fingers, and a stiff wrist represent such progress as compared with amputation, that a conservative procedure should always be tried before resorting to more drastic measures. Therefore, before discussing the question under consideration, we consider it proper to mention briefly the methods by which the aim previously mentioned can be attained and mutilations avoided.

Our endeavors are unsuccessful, of course, in many cases still,

* Read before the International Society of Surgery, April 13, 1914. Translated from the German by Oswald Joerg, M.D.

especially in *lesions* in which severe contusions exclude conservative treatment. More frequent use is constantly being made of the newest acquisitions of science which make possible not only the replacement of tissues and organs, but also of the extremities, as shown by *Carrel's* experiments.

In traumas, mutilations are often unavoidable, but in the case of inflammations, mutilation can in many instances be avoided by proper knowledge and experience, and with the aid of all the recognized procedures at our disposal hands and fingers which, ten or twenty years ago, would under all circumstances have been sacrificed, can nowadays be saved and even restored to usefulness. *In acute processes* many hands and fingers have been restored to their full working capacity by means of a prompt and energetic but cautious operation, care being taken not to injure the bone, the tendon sheath, or the joint, by means of rest, or by the use of *Bier's* treatment, or possibly even by the application of serotherapy, or *Bacelli's* bichloride of mercury treatment.

However justifiable in *acute inflammatory processes* prompt, energetic, but cautious measures may be, an attitude of patient observation is both advisable and justified in the care of *chronic* and especially tuberculous processes. Especially good results have been obtained, particularly in surgical tuberculosis, by means of *Rotter's* heliotherapy; now that this method can be successfully applied in the care of the hand, it is our duty first to try it in each case.

From our own experience, also, we can mention cases in which absolute rest and insolation have cured hands considered incurable because of the processes affecting the carpal and metacarpal bones; to be sure, the wrists remained stiff, but the fingers were able to work. Two cases under my observation came under my treatment in a totally neglected condition, with several fistulæ, indicating mixed infection, and the patients themselves wanted the amputation. On my advice, however, a conservative treatment was applied and after months both left the hospital cured and happy.

With regard to cases in which only some of the metacarpal bones or phalanges are diseased (spina ventosa), or if a conservative treatment does not lead quickly enough to the desired result, or if it is feared that the affection will spread to the soft parts, the attempt may be made to replace the diseased bone by a piece of bone covered with periosteum (tibia, ulna, radius). In this way we save the finger otherwise deprived of its support. This method must be applied in such cases for the reason that parts of bones can be transplanted only in healthy soft parts. Insolation can also be supplemented by specific vaccinations.

In the *technic of amputation of the hand, fingers and individual parts of the fingers,* our principle is, except for a few changes, still the same as for the larger extremities, namely, to endeavor to insure the greatest possible serviceability of the stump, *i.e.,* to reduce to a minimum the disability which it causes the patient. In preparing the flaps covering the wounded surfaces we should see to it that the *cicatricial line* falls on the least exposed part of the stump. Therefore, we should take pains in amputations of the hand and fingers never to bring the cicatrix on the *volar side* of the palm. This is especially important in the amputation of the metacarpal bones.

While scars on the palm impair the grasping ability of the hand in the case of the fingers, it is the sense of touch which is influenced by scars on the side of the flexors.

In order to insure the greatest possible recovery of mobility in the fingers and wrist Rioblanc, Koch and Wilms recommend (Kocher even insists upon it) that, in amputations of the fingers and phalanges, the *stumps of the tendons be united over the stumps of the bones.* On the other hand, Beely considers it entirely sufficient for the purpose to fasten the tendon stumps only into the connective tissue or the fascia. Beely's procedure cannot replace that of Rioblanc, Koch, Wilms and Kocher, inasmuch as in the latter case the joining of the tendon stumps not only makes for their attachment, but the skin also gains a foundation, while with Beely's method the flaps of the skin tighten close to the bone as a result of the retraction of the tendon, a fact which can also impair the undisturbed healing process of the wound.

Although few adherents will be found, Vanghetti's method should also be mentioned, which he recommended in the case of a congenital lack of the forearm. Vanghetti makes nooses out of the tendon stumps and covers them with skin. These nooses, he claims, would be fit to hang things from, a measure that would increase the utility of the stumps.

The different disagreeable complications of the older methods of amputations: exostosis in consequence of hypertrophy of the callus, the formation of neuromata arising from the fixation of the nerve stumps in the cicatrix, which often renders impossible the application of artificial limbs, the neuralgic pains which occasionally appear and embitter the life of the patient,—all of these can be, as it were, entirely avoided by the newer methods. Experience and especially the employment of Röntgen rays have shown that Langenbeck's subperiosteal method does not prevent the formation of exostosis and large masses of callus even in those cases in which the whole surface of the bone

wound had been covered with periosteum. Experiments have therefore been made to do away with these serious complications. Bier's idea—the osteoplastic covering of the bone—solved this question, and this method is applicable in every amputation, because it suffices if the osseous lamella, taken out of the part of the bone which has to be amputated, is connected only by means of a periosteal pedicle with the remaining part of the bone. The preparation of the osseous lamella, however, involves some technical difficulties, for often the osseous lamella necroses and must be removed, or in some amputations, such as the finger metacarpal bones, this procedure is hardly feasible, and for this reason we welcome whatever newer methods attain this end with ease and under all circumstances. To these belongs Hirsch's proposal to detach the osteoplastic periosteum from the osseous stump, in addition to which Bunge scoops out 3 to 4 c.c. of bone marrow in order to prevent ossification through the latter. This procedure has, in practice, proved itself feasible; for through Hirsch's and Bunge's methods even the stumps of the legs can be made capable of bearing weight. Recently, Ritter recommends covering the bone with fascia so as to avoid the formation of the disagreeable callus. This procedure answers its purpose also. Both of these methods are very well applicable in amputations of the hand and fingers.

To prevent the *formation of neuromata* as well as the growth of the new stump into the cicatrix is the aim of numerous proposals. Cushing recommends the union of the nerves, Ritter the removal of the centre of the nerve stump and the joining of its edges. Bardenheuer turns the end of the nerve and sews it into the nerve trunk. Witzel recommends the amputation of the nerve stump high up. Except for the last method the general tendency is to cover the wounded nerve termination approximately; by this means the formation of a neuroma is avoided. This tendency is very praiseworthy but not always possible. The technical difficulties are especially great in the case of the hand and the fingers, where the procedure of Witzel is the most appropriate; for if a neuroma is found, it is situated a great deal higher up, far from the stump, so that, lying in the soft parts, it does not cause any inconvenience.

In conclusion, the question may also be brought up, whether in a given case *enucleation* or *amputation* is preferable, especially in those cases where the removal of larger parts by amputation or exarticulation does not materially affect the use of the hand. This question must be decided according to the social position of the patient, for if in a given case, for instance, the thumb is sound and the fingers are

to be removed, we will enucleate the stumps of the fingers, if the patient is a workman, whereas with a patient of the better class we must try, if possible, to save parts of the first phalanges so as to avoid the displacement of the artificial fingers when covered with a glove.

If, on the contrary, single fingers are to be removed we do not content ourselves with a simple enucleation to prevent the callus; the capitulum of the metacarpal bone must also be removed, partly for cosmetic reasons, partly because the interstice resulting from the simple enucleation disturbs the ability to grasp objects. In removing, *i.e.*, enucleating, the hand the processus styloidei of the forearm bones may either be taken off or left intact, as the uneven articular surface, if covered with a sufficiently padded flap, will not render it difficult to carry the prothesis, and the formation of a disagreeable callus, with its possibility of causing pressure, can thus be avoided. But if the principal flap is thin, it is advisable to saw off the processus styloidei and to cover the stump with the fascia. In sawing off the processus, respectively the articular surfaces, we must take care not to open the radio-ulnar articulation, as a lesion of it might unfavorably influence the pronation and supination of the forearm.

From the aforesaid it will be seen that all the great surgical advances as well as the general rules and successes of amputations are equally applicable to the hands and fingers and thus the limit of cases where amputation is indicated has been considerably reduced. Nowadays we are able to save hands and fingers, to restore or at least greatly to improve the usefulness of these members also in cases in which two decades ago a cure could be achieved only by amputation.

AMPUTATIONS OF THE LEG*

By John Fairbairn Binnie, C.M.

of Kansas City, Missouri

The level at which an amputation of the leg is performed below the knee has no influence on the vital dangers of the operation,[1] hence the choice as to the method and site of such an amputation depends first on the lesion for which the operation is required and second on the use which is to be made of the resulting stump.

I. The old general rule that amputation for malignant disease of a bone must remove the *whole* of that bone makes it evident that for such disease situated in the bones of the foot, amputation at any convenient part of the leg and by the best possible method is proper, while for the same disease of the tibia or fibula no amputation below the knee can be considered.

If gangrene is the occasion for the amputation, the site of operation will depend largely on the extent of the vascular disturbance and this is best determined by the use of Moskowicz's method of examination. Elevate the limb for two or three minutes. Apply an elastic constrictor (not too tightly) as if for amputation and lower the limb to the table or into a dependent position. After five minutes remove the constrictor rapidly. In health the arterial circulation is reëstablished at once and a hyperæmic flush passes down the limb to the toes in about two seconds. If gangrene is present the flush rapidly passes a certain distance down

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* Read before the International Society of Surgery, April, 1914.

[1] Estes' statistics (Annals Surg., July, 1913) seem to show that amputations through the middle of the leg are less dangerous than those through the lower third and that both of these are safer than amputations through the upper third of the leg. At the same time they show that an amputation through the knee is less dangerous than one through the upper leg. A glance at his table shows that, while his figures are of course correct, the above conclusions regarding dangers may be entirely fallacious because, while he happens not to have had a fatality in 58 amputations through the middle of the leg, he has had one and only one in each of the other classes.

		Cases	Deaths
Amputation through the	lower third leg	105	1 = 0.95 per cent.
	middle third leg	58	0
	upper third leg	29	1 = 3.78 per cent.
	knee	32	1 = 3.03 per cent.

the limb, then pauses so that there is a clear line of demarcation between the hyperæmic skin above and the ischæmic skin below, then the flush slowly passes downward, taking minutes instead of seconds to reach the toes. *The line where the descending flush pauses* corresponds to the site of arterial obliteration and the limit to which the gangrenous process may be expected to reach. The amputation must, of course, be performed well above Moskowicz's line and the choice as to site of operation may be therefore exceedingly limited.

Sandrock's method is much simpler than the preceding.[2] Scrub the leg vigorously in preparing for operation. Note the reaction of the skin to the scrubbing. The well nourished skin becomes diffusely red and this flush stops more or less abruptly at the poorly nourished level.

When the change is less abrupt, the transition zone shows either spotted or streaky redness. It may be necessary to wait a minute before reactive hyperæmia appears and it must be watched closely as it sometimes disappears rapidly. It is advisable to repeat the experiment on the healthy limb as a control.

When amputating for trauma the site of section depends on the site of injury and the amount of tissue which is left and which is suitable for forming the stump.

II. The use which is to be made of the stump is a factor of prime importance in the choice of the site of amputation.

A. If the financial condition of the patient is such that he cannot afford to indulge in a more or less expensive artificial limb, then it is of vast moment to save as much of the limb as possible and to provide him with a good stump, *i.e.*, one which will withstand abuse and on which the weight of the body can be directly, both continuously and intermittently, supported without harm resulting. This is the reason why so many excellent operations have been devised by which the heel is wholly or partly saved in amputation of the foot even although the result does not lend itself to the wearing of a comely artificial foot. The types of these amputations are Syme's and Pirogoff's, the latter being osteoplastic and having very many variants. In the same class of patient when amputation of the leg is required, it has been wise to do it at the so-called " seat of election."

The " seat of election " for bone section is one hand-breadth below the top of the tibia or about one inch below the tubercle of the tibia. At this level the flaps are almost always well nourished and the stump of

[2] *Zentralblatt für Chir.*, 1913, No. 27.

the leg is long enough so that the patient can support his weight on the bent knee without the end of the stump projecting too far behind. A wooden peg with a padded shelf at its upper end on which the patient kneels with his stump, makes a useful and inexpensive artificial limb. The "seat of election" is quickly becoming a misnomer because improvements in the methods of operating are giving stumps on which direct pressure can be safely and painlessly exerted.

B. The patient can afford a good artificial limb.

Most artificial limbs are fitted to the stump by means of a bucket accurately moulded to the expanded upper end of the tibia; the lower portion of the stump merely occupies the hollow interior of the apparatus. Makers of artificial limbs consulted by the writer have stated that the lowest favorable site for section of the leg bones is eight inches above the ground and the highest point is about four inches below the lower edge of the patella. The improvements being made in the weight bearing efficiency of stumps must lead to the simplification and improvement of artificial legs. Now the main efforts after improvement in the technic of amputations are directed toward saving as much of the limb as is possible and providing an efficient weight bearing stump. If we can consistently secure an efficient weight bearing stump at any level, then it follows that for one who cannot afford a good artificial limb it is important to have no shortening of the leg; hence a Syme's or a Pirogoff's amputation is the best when feasible. If, however, a good artificial foot is procurable, it is better to amputate at a higher level so that there may be room between the stump and the ground for such an apparatus. From the ankle to the so-called seat of election it does not seem to matter much at what level amputation is performed, except that if the stump be of the proper weight bearing variety the more leg there is below the knee the greater power ought there to be in it.

If disease and circumstance demand that amputation be performed at a level higher than the "seat of election," then it has usually been advised to disarticulate at the knee as the articular end of the femur is accustomed to weight bearing and the portion of leg left below the knee is not long enough to be attached to and operate an artificial leg in such a manner as to use the normal knee motion.

Franke[8] has pointed out that the flaps of soft parts required to cover the expanded femoral end must be very large and thus difficult of nutrition; hence he has devised an osteoplastic operation similar to

[8] *Zentralblatt für Chir.*, 18, January, 1913.

Bier's in which the tibia is divided immediately below the joint but the joint is left intact—by this procedure the flaps do not require to be so long, there is less danger of necrosis and the weight bearing ability of the stump is excellent.

When part of the foot requires to be amputated, the position of the line of bone section or disarticulation is of much importance. If it is safe and feasible to leave enough of the foot so that a shoe can be worn comfortably and use can be made of the ankle-joint, then there is no doubt as to the propriety of such an amputation.

Estes is a strong advocate of mediotarsal amputation and states that such a stump can be fitted with a thoroughly comfortable and practical artificial foot.

An artificial foot can be fitted to any good form of ankle amputation, but is said not to be so satisfactory or efficient as one fitted to a supramalleolar amputation.

The causes militating against efficient weight bearing capacity of a stump are:

1. Adhesions of the skin, etc., to the bone.
2. Inefficient covering of the bone (scanty flaps, conical stump).
3. Irregularity of the end of the bone either from faulty division of the bone or from irregular callus formation.
4. Stump neuromata and inclusion of nerve endings in scar tissue.

Many, if not most, of these faults may be due to the condition of the patient (*e.g.*, trauma) demanding immediate operation and denying opportunity to carry out any complicated procedures.

Furthermore, endeavors to preserve as much of the limb as possible may force the surgeon to operate through tissues not entirely above suspicion as regards infection and vitality, as impaired by trauma or disease.

There are several means besides cleanliness of avoiding the above-mentioned faults:

(*a*) In dividing the soft parts first cut through the skin and fat down to the deep fascia, let the skin retract and then, cutting through the deep fascia, reflect it along with the skin; second, cut through the muscles obliquely upward and toward the bone, so as to make muscular flaps which will cover the bone evenly and themselves be smoothly covered by the fascia and the skin (J. N. Jackson).

Kocher long ago emphasized the necessity of accurate suture of the deep fascia. In amputations by transfixion the fascia is utilized as a matter of course.

(*b*) Hirsch and Bunge very strongly recommended that, after the

bones are divided, they should be stripped of their periosteum for a short distance and Bunge recommends that the marrow be scraped out for a distance of about one-third of an inch. This practice, diametrically opposed to the older teachings, seems to lead to the formation of painless stumps, the periosteum and, according to Bunge, the endosteum being the source of tenderness in the stump. Kocher and J. M. T. Finney vigorously support the views of Hirsch and Bunge.

(*c*) When the wounds have healed everyone believes that it is wise to subject the stump to a reasonable amount of therapeutic abuse. Hirsch [4] systematizes the abusive treatment very satisfactorily. He keeps the limb horizontal or in an elevated posture and either repeatedly hits the end of the stump or has the patient bump the stump against a board. After indulging in this kicking exercise sufficiently, the patient rapidly and frequently flexes and extends his knee so as to stimulate circulation. After a few days of exercise in bed the patient may repeat the exercises in the upright position and use the stump to support himself; after each seance of exercise he must lie down and elevate the limb. Before long even a rather poor stump may gain good weight bearing power by the above means. When time and conditions permit, one of the *osteoplastic* methods of amputating is to be chosen, for by such means a good weight bearing stump is almost sure to be quickly obtained. The importance of improving stumps is shown by the statistics published by Bräunig.[5] He found that out of 122 amputations of the thigh and leg only a small number were able to bear their weight on the stump. In the majority of cases where Gritti's or Pirogoff's operation had been done the patients could walk on the stump even if there had been infection.

Crainer, quoted by Kocher, found in 92 diaphysial amputations of the thigh and leg, 70 with bad stumps and only 2 with weight bearing efficiency.

It would be useless to describe or even mention the numerous variants of Pirogoff's classical operation at the ankle or to describe Bier's equally classical method of amputating the leg, they are familiar to every surgeon. To the author it seems that Bier's osteoplastic operation and its variants are needlessly complicated and difficult. It is difficult to elevate the flap of bone by which the sawn end of the tibia is covered, it is difficult to make the proper periosteal hinge by which the flap is permitted to be turned over the tibia like a lid, and during

[4] *Archiv für klin. Chir.*, lxi, 743.
[5] *Deutsche med. Woch.*, 1912, p. 2071.

the necessary manipulations it is difficult to keep the flap of bone from falling off its periosteal covering.

The flap or fragment of bone can get no nourishment from its periosteal covering and hence the periosteal hinge is of no use except *as a hinge* and this function is of no value in comparison with the difficulty of making and keeping it.

The writer has come to the conclusion that all the advantages of the Bier's operation can be easily and safely obtained by covering the cut end of the tibia with a *free* transplant of bone.

He has operated as follows: By any of the customary methods (preferably a flap method) reflect the soft parts and so expose the tibia covered by its periosteum for a few inches below the proposed line of bone section. Transversely divide the periosteum of the tibia along two lines separated from each other by a space about one-half inch greater than the diameter of the bone. From the upper incision separate the periosteum downward for about two-fourths inch. From the lower incision separate the periosteum upward for about two-fourths inch. Cut through the cortical bone of the tibia transversely at the base of the periosteal flap. With an osteotome or Gigli's saw cut free the plate of bone between the transverse incisions. This plate of bone is covered by periosteum which hangs from its upper and lower edges like a tablecloth. Preserve this in warm salt solution. Complete the amputation by sawing through the bones after forming a periosteal cuff on the tibia. Place the plate of bone over the cut surface of the tibia and fix it there by periosteal sutures. The tibia and the plate might be united by chromicized catgut sutures introduced through drill holes instead of by periosteal sutures.

If desired the bone plate may be made long enough to cover the cut surfaces of both tibia and fibula, extending between them like a bridge.

As has been already stated, such an operation as the above is entirely out of place unless asepsis can be assured and the resisting power of the patient is satisfactory.

FREE TRANSPLANTATION *

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Free transplantation viewed clinically is of different significance than when looked at from the stand-point of the pathological anatomist, so that the question, What is meant by a success in free transplantation? may be and is answered in a different manner by the clinician and the pathologist. Thus the histologist may describe as a result of his microscopic examination, failure in the healing processes, in a case in which the surgeon has obtained a successful result, clinically. If a clinical success were dependent on the pathologist's conception of successful transplantation, the surgeon would achieve success only rarely.

The structure of the transplanted tissue varies in the successes as it does in the failures.

What eventually becomes clinical success can be grouped as follows:

1. The approach to the ideal, where healing of the tissues takes place. Histologically, not only are the masses of cells held together, but vigorous regeneration occurs at the site of the wound flap, where necrosis usually is noted.

2. Healing occurs with a gradual disintegration of the transplanted tissue, but with coincident regeneration of the homologous tissues of the recipient, from those in the immediate vicinity. This condition is a most important one. The best example of it is seen in fresh transplanted bone which gradually disintegrates, slow regeneration taking place from the periosteum of the bone in which it has been implanted.

3. Healing takes place with complete encapsulation. The transplant here breaks down completely, but retains its shape. It becomes isolated like a foreign body, surrounded by a capsule so firm that neither absorption nor substitution can take place. In spite of this condition the clinical result may be a successful one, as, for instance, where fragments of bone are used to obliterate cavities, or when tendons or fasciæ are employed as bands.

In the clinical failures one meets with the following variations in the structure of the transplant:

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1. The transplant may be exfoliated after a few days, with suppuration. The cause is not a wound infection, but a malignant, non-bacterial suppuration, so severe that a gangrenous reaction may be the outcome. This is not seen very often, except when man-to-man transplantation is performed and the donor is suffering with tuberculosis or syphilis. For this reason such individuals are not desirable subjects for transplantation.

I believe in this class of patients who present themselves mostly for homo- or heteroplasty, that the difference in the serum and the cell proteids is markedly increased.

2. There may follow after healing a slow suppuration due to the foreign body, which ceases only when the tissue mass has become completely isolated.

3. A failure may occur after initial healing, because absorption takes place at a more rapid rate than does regeneration from the surrounding tissues. A not infrequent example is seen in transplanting the articular surface of the long bone of the arm, which has been denuded of its periosteum, where the bone is absorbed faster than new bone is generated.

4. After apparent healing occurs there is a disappearance of the tissue with cicatrization. In this instance the clinical result may be successful, as when tendons are transplanted, scar formation takes place, and they regain their normal function.

Aside from the bacterial and suppurative obstacles, one meets with other undesirable processes, as when the tissue mass becomes necrotic because of exuberant granulations which interfere with the blood supply, resulting in suppuration, absorption, and cicatrization.

The clinical result also depends on the type of tissue mass to be transplanted, as the more complicated in structure the tissue the more can we expect ideal histological healing. All types of tissue, as connective tissue, fasciæ, tendons, fat, tubular vessels, peritoneum, cartilage, and bone can be made viable in the homologous tissue of the recipient, and its regenerative powers increased with a consequent successful result, provided that substitution keeps pace with absorption.

It is common knowledge that the best results are obtained by means of autoplasty, in which method the transplanted tissue is grafted into the body from which it has been obtained. One must not believe, however, that a success in the histological sense is always obtained even in autoplasty, as here also come into play the variations in the site of the graft, the condition of the wound, as well as the damage done to the transplant. Only in autoplasty of the complicated tissues, as in trans-

plantation of organs, is a successful result always possible, in the clinical sense.

In homoplasty, *i.e.*, the transplantation of tissues from one animal to another of a like species, success has been achieved only when the transplanted tissue was homologous to the mother tissues in the following types of tissues, connective tissue, fat, bone, etc.; never with nerves, muscle, and organs, in which instances rapid degeneration and cicatrization occur. Fibrous encapsulation is met with more frequently in homoplasty than in autoplasty. This is probably due to the irritation of a foreign proteid, a difference, varying mostly with race, then with distant relatives, near relatives, and least with the individuals of one family. This variation prevents proper nourishment of many tissues, and, as a result, substitution in the regenerative process occurs very slowly while degeneration takes place very rapidly.

In heteroplasty, *i.e.*, transplanting from lower animals to man, or from an animal of one species to an animal of another species, scant success has been obtained. Küttner has been somewhat successful in transplanting tissues from the ape to man. The tissue mass necroses as it does in homoplasty, except that, according to Schöne, the transplanted material can be grafted after a few days into the donor with healing.

A survey of the above circumstances governing the behavior of the transplant makes it evident that the solution of the problem to obtain a successful result lies in the study of the properties of the tissue to be transplanted.

1. It must have the ability, when it is transplanted, to grow upon the foreign soil. The first factor is the viability of the tissue, as it is dependent upon its own lymph and circulation for nutrition. This viability varies with the individual tissue, as the higher the development of the cell—as the ganglion cells, nerve cells, muscle cells or parenchymatous cells—and the richer the tissue is in blood-vessels, the less likely it is to survive. On the other hand, the life of some tissues survives the life of the body as a whole. It is thus possible to transplant successfully such tissue from a corpse to a living organism.

2. The transplant must be endowed with the capacity for extracting nutrition from the soil into which it has been planted.

3. It must be able to regenerate so that the disintegrating tissue is replaced.

These properties are present very markedly in the malignant tumors and in cultures of living cells, as shown by Harrison, Carrel, and Burrows.

Even in tissues rich in the above mentioned qualities, it is important to know by what factors they are influenced. In removing and implanting the graft, many factors can easily enter which either weaken or destroy these properties, as drying, chemical contact, or mechanical injury. The practical surgeon who guards against such factors achieves the best results.

As important as the properties of the transplant are the qualities of the " wound soil " which serves the function of supplying as quickly as possible nutrition to the graft. The first step in the establishment of the lymph flow and the circulation is the early adhesion between wound edges and the transplant. The more quickly and surely this takes place, the more promptly is nourishment assured. Should the cells of the wound be injured because of antiseptic applications, or should they be abnormal because of the presence of scars or hæmatomata, or the seat of previous disease, as tuberculosis, necessary nutrition will be delayed. Very important contributing factors to failure are errors in operative technic, causing infection with a very slight transudate, which is instrumental in destroying the first intimate contact, thus preventing nutrition, partially or absolutely, and predisposing to partial or total necrosis due to suppuration. By means of strict asepsis, this element of failure can be eradicated. Most important, however, is a second factor, which prevents the early intimate adhesion of the wound edges, namely, imperfect hæmostasis. The presence of the slightest amount of blood is dangerous, as it interferes with the nutrition. That this factor has been heretofore disregarded is apparent from the literature. It is the general belief that a smooth, uninfected wound is a sign of perfect technic. This is not true in connection with transplantation. In this instance perfect technic is recognized by a complete gumming and coaptation of the wound edges. For this reason every experimenter in recording the results of his transplantations should convince himself that the transplant is really grafted as it should be, in order that his operation be perfect.

In order to perform transplantation the following rules must be observed:

Strict asepsis, complete hæmostasis in the wound, care in removing, handling and implanting the graft. To this add my rule—the improvement of the nutritive properties by prevention of suture lines, by placing flaps or small pieces of subcutaneous tissue or skin immediately over the graft.

During the after-treatment functional dressings, as advised by Roux, are important, as weighting of bones, stretching of tendons.

SKIN AND EPIDERMIS TRANSPLANTATION

The technic is well known and various methods are applied toward the common end. It is only necessary to emphasize that in my experience where there is present granulation tissue it is better razed with a knife than with a spoon, not interfering with the recent necrotic tissue. Not only do I believe this to be a better procedure, but I make it a rule never to plant epidermis on granulation tissue without previously freshening the base. To secure hæmostasis, I adopt the following procedure: after ligation of the visible bleeding vessels, I allow the wound to remain uncovered until there is visible fibrin formation. Then I exert pressure over the surface with a gauze sponge moistened with warm saline solution. As a result all bleeding is brought to a stop, so that the capillaries come in intimate contact with the grafted flap.

The application of strips of epidermis to repair large areas of skin wounds is made possible—especially where prevention of scar formation is sought. This is of importance on the face and about the joints. The indications for epidermal transplantation are of less importance in those regions of the body where the skin contracts or where it cannot be closely fitted, with consequent disability or disfigurement, as on the scalp, forehead, or flank.

Substitution of epidermis for mucous membrane is not practical, since infection and secretion interfere with the healing processes. In the body cavities it has been tried without success, as in the repair of dural defects.

The successful epidermis transplantation terminates in healing with a smooth, pale, and soft skin surface. Uncommonly, one observes a scar-like thickening of the corium with ugly swellings and intense hyperæmia. This is found following the freshening of old wounds, and, in my opinion, in the tuberculous and in those susceptible to keloid formation.

Where epidermis is contra-indicated on account of previous cicatrization with shrinkage of the skin, transplantation of the skin finds its usefulness. Skin transplantation dates back to the Indian times, but its usefulness was first brought to notice in the last century by Bunger (1818), Wolfe, v. Zehenden, v. Langenbeck, and v. Esmarch, when the importance of mechanical sterilization was recognized and finally emphasized by the work in strict asepsis of Fedor Krause. Here also I will not go into detail regarding the technic, as it is well known.

It makes no difference whether one follows Krause, in removing

the flap without fat, or v. Esmarch, in using the fat with the flap. According to Hirschfeld, healing takes place as well with or without the subcutaneous adipose flap. Finally, as I brought out, I made use of padded flaps, as in the repair of facial skin.

For successful healing to take place, the primary adhesion of the flaps is essential. Should this intimate contact and glueing be disturbed within the first twenty-four hours, on account of bleeding or inflammatory transudate, death of the flap usually occurs, followed by marble-like areas and cicatrization as a final result. I have, on some occasions, seen this occur after primary adhesion in cases of post-operative erysipelas, scarlet fever, or measles.

To obtain a successful result, all pre-existing scar tissue must be removed from the surface of the wound, in order to prevent contraction of the flap.

Attachment of the skin occurs more slowly than that of epidermis, the former occurring in from three to five weeks, the latter in one to two weeks. Sensation manifests itself in the edges after about six weeks. Transplanted hair sheds, regenerating only rarely. Transplantation of hair flaps, for example, of the scalp, the pubic skin, or the axillary skin, for the repair of the eyebrows or upper lip, is not attended with certain cosmetic results.

Like the hair, finger-nails with the contiguous skin do not lend themselves to successful transplantation, as Nicoladoni first demonstrated. Even with favorable nutrition of the nail bed, the shape and the growth are abnormal.

The advantage in the use of strips of epidermis over skin flaps lies in the certainty and rapidity with which repair takes place. If all precautions are observed, healing occurs in every case of epidermis transplantation. This certainly does not pertain to skin transplantation, but failure is not always due to faulty technic. In some individuals failure is due to some factors not yet clearly understood. I believe, as the result of my clinical experience, that there are patients in whom, after skin transplantation performed with strict observance of all rules, absorption of the flap with scar formation occurs, or in other instances, necrosis and suppuration with shedding of the flap, there remaining only a few small islands of skin. These results have been noted mostly in the anæmic, in the tuberculous, syphilitic, or diabetic, while drying of the flap occurred mostly in those of advanced age.

The advantage of skin flaps over epidermal strips rests in the greater resistance of the former, since it contracts less and affords a

better cosmetic effect. For this reason I prefer to use skin flaps on the face and fingers.

The important indication for skin transplantation is in the repair of skin defects. Within the body, *i.e.,* for the repair of peritoneum, pleura, or capsule of joints, skin flaps are not useful. The sequelæ usually consist in epithelial cysts and tumors, following encapsulation of the detritus mass of the absorbed epithelium and secretions.

Independently of one another, Lowe and Rehn conceived the idea of utilizing the connective tissue of the skin as a substitute for the repair of fasciæ and tendons. Later, following Lowe's observations, it was found that by abrading the layer of epidermis much detritus was formed, especially from the deep sebaceous glands and hair follicles. Rehn's idea seems better, *i.e.,* to stretch the flap by means of artery clamps and to remove the epidermis with a knife. Should broad skin flaps be needed, as from the upper portion of the thigh, the epidermal layer is first removed with a transplantation knife, the cutis and subcutis being obtained by a second incision. This layer is then implanted on the recipient soil. As Rehn has demonstrated, very large and broad tendons and bands and many connective-tissue areas can be repaired with the abundant material that can be obtained from the edges of wounds made on the operating table. I have been able to use this material for padding out the tip of the nose and the alæ nasi, as well as to utilize the skin of the arm to build up an entire auricle, constructing a solid elastic plate.

These favorable results in epidermis and skin transplantation have been obtained only in autoplasty. Regarding the value of homoplasty, the conclusions are still uncertain. As the result of clinical observations and animal experimentation, I am compelled to say that homoplasty does not yield good results. And the reports in the literature of fortunate healing of transplanted skin or epidermis by homoplasty, as well as the reports of implanted skin or epidermis from the dead body or from animals, are the result of erroneous observation.

This remark also holds good for the reports of successful transplantation of negro skin on the Caucasian, or *vice versa,* as I believe that the pigmentation occurring in the former case is the usual pigmentation seen after ordinary transplantation, and the light color seen in the negro is due to the scar, which in the negro is never pigmented. In the light of our present knowledge, the status of homoplasty and heteroplasty can be summed up as follows:

Histologic evidence which shows proof of healing has not been brought forward. Clinical evidence has been offered, but this evidence

is misleading. Healing has been accomplished by replacement of the flap with normal skin, or the flap has been lifted away by the secretions of the sebaceous and sweat glands at the borders of the defect, with new skin growing under the raised flap: this has been interpreted as successful transplantation. Others have observed that in heteroplasty, for example, of hair or chicken skin with feathers, these skin accessories have grown but for a short period of time. De Francesco has noted the appearance of small feathers, and Perinoff has observed the growth of hair for twenty days after homoplasty. As a result of animal experimentation, Davis allowed himself the conclusion that homoplasty was equal to autoplasty, after Marchand, Henle, Wagner, etc., had expressed themselves against it.

In order to clear up this aspect of the subject, I suggested a number of new animal experiments (Oshima), and for many years have conducted many homoplastic dermal and epidermal transplantations with fresh human material. This was done in operations where the opportunities offered themselves, as in amputations of limbs. In all cases the wounds were covered with strips of skin, care being taken not to allow them to come in contact with the wound edges, and side by side with the homoplastic flap were placed autoplastic flaps of either skin or epidermis. By this means both types of tissue were subject to identical conditions.

While there was noted degeneration of the skin flaps with scar formation in the animals, the clinical experiments were also negative. In the clinical failures, however, not only was the flap shed, but it was shed in a striking manner, with acute gangrene.

Second, shedding of the transplant occurred as the result of a thick pus layer, which originated from the exuberant granulation of the wound—this being noted after apparent adhesion and healing in from one to three weeks. Perhaps an attempt at nutrition took place after an initial adhesion but was prevented by the formation of granulations. The entire process is suggestive of that which occurs in foreign body suppuration and shedding.

The third method of shedding is noted when, after the third week, following apparent healing, liquefaction of the dried epidermis or skin flap occurs without pus production. As in scab healing, the liquefaction occurs under the necrotic flap, when the floor of the wound has been covered with new skin. It is true that the latter appears under the protection of the flap but it is created by the body tissue, namely, from the cell rests of the skin and from the edges of the wound of the recipient.

Formerly, a frequent observation was the appearance, during or after the fourth week, in an apparently well-healed skin flap, of strange, red, scaly areas in the epidermis resembling pus. As the flap contracted because of cicatrization, these red areas became larger and changed their positions in the scar tissue. It became macroscopically evident that one dealt with production of granulation tissues scattered throughout the flap, as with the mechanical motion this tissue would bleed. Microscopical examination of the above described skin flaps showed this structure up to the forty-fifth day. This scar formation, I believe, is the best possible result, excepting scab formation (natural substitution), that one can obtain from skin homoplasty.

I obtained favorable results only with epidermal flaps from the fresh fœtus. Here was seen plainly enlargement of the epithelial islands after the superficial layers desquamated. In spite of this attempt at regeneration from its own resources, the entire flap was cast off in the third week. Exactly similar results were obtained by Stern in his experiments with the amnion.

After these experiments I regard the usefulness of homoplasty in extreme doubt, and believe that the above-mentioned conclusions are the results of faulty observations, and the new skin formation, interpreted as implantation, is the result of scar substitution under incrustation of the flap. This does not exclude the fact that the foreign epidermis acts as a stimulant to the proliferation of the cells of the recipient. There is even greater doubt of the possibility of skin transplantation from the corpse, as reported by Gluck.

The inherent virtues of the homoplastic transplant are important factors in this consideration, since the structure of the donor's cell protoplasm undergoes early softening, resulting in healing by substitution with scar formation. I have proved clinically that racial differences play an important part, by using the skin from a freshly amputated limb of a Slav and implanting it on other individuals. In a Prussian, suppuration followed, while in a Slavish child healing with scar formation occurred. The most possible favorable result was met with in like races. More encouraging results were reported by Schöne in transplantation in animals that were blood relations, since skin flaps could be easily interchanged between near relations of like sex. In the human family I have never applied homoplasty that was not free from subsequent objection.

There is no question that it is of clinical importance, if it were possible to prove the conclusions which have been advanced relating to the successful grafting of homoplastic flaps of skin; and if it is true

that homoplasty yields results as certain as does autoplasty, we might soon look forward to transplantation of other tissues by this means.

Up to date experiments in this connection, mutual immunization of donor and recipient, etc., have failed. In my clinic, certain complicated investigations in animals in connection with homoplasty and heteroplasty gave only partial results, none of which was permanent. Donor and recipient were immunized against one another's sera, and during the transplantation operation and while healing was in progress serum from the donor was injected under the graft. It was thus possible to obtain perfect adhesion, with a consequent result that the flap held for a longer period of time, *i.e.*, for about eight weeks. The size of the injections was diminished, so that while the flap received its accustomed nourishment, it had a chance at the same time to accommodate itself to the changed conditions. Whether or not anything more can be accomplished along these lines remains to be seen.

MUCOUS MEMBRANE TRANSPLANTATION

The obstacle to healing in mucous membrane transplantation lies in the infected surface upon which the graft must be placed, the results being more unfavorable than in skin transplantation. One can perform blepharoplasty by implanting a free or pedunculated flap of skin and mucous membrane from the lip. Utilization of portions of intestine as flaps naturally results in fistulous tracts in the wound.

Stressler and I independently have made use of the normal healthy vermiform appendix of a patient for the repair of a congenital or acquired defect of the urethra.

In a man of twenty-seven years, I found cicatrization of the bulbous portion of the urethra after rupture with leakage, the lesion also being the site of a large abscess. After excision of the stricture, there remained a urethral defect eight centimetres long. The healthy appendix of the individual was removed, the interior was scraped carefully, and the serous and muscular coats were stripped, in order to encourage nutrition through the medium of the raw surface. After the open lumen of the base of the appendix had been sutured to the central extremity of the urethral defect, the tip was drawn through the urethra by means of a suture. To prevent the flow of urine over the implanted tissue cystostomy was performed. In spite of the fact that no sounding was done, the patient, two and one-half years later, still has a normal stream. He testifies that after healing occurred there was no appreciable contraction of the graft, and at no time was there obstruction to the urinary flow.

One cannot expect satisfactory healing in every case, as the condition of the wound may not be favorable for implantation after the injury, since it is then the seat of scar tissue. The conditions of the soil are even worse in congenital defects. It is an absolute necessity to prevent the flow of urine over the graft for some weeks by means of a bladder fistula.

Mucous membrane homoplasty, in the experience of Axhausen and myself, yields no better results than those described under the skin. Legeuer and Tanton report successful transplantation of vaginal mucous membrane to repair the urethral defect of a male, but admit that sound dilatation was needed, and that six months later (the present time) sounds are still being used.

The field of usefulness of mucous membrane transplantation is not large. One must have recourse to the use of pedunculated mucous membrane flaps when large defects are to be repaired, as in the mouth, cheek, or bladder; or to pedunculated flaps of skin for others.

FAT TRANSPLANTATION

Fat transplantation was attempted with success by Czerny in 1893, when he implanted by autoplasty a lipoma on the wound surface following a breast amputation, thus substituting the lipoma for the breast tissue. Axenfeld, Neuber, and Bier also tried a similar procedure with small pieces of fat.

The first transplantation of large flaps of fat, as well as the therapeutic application of this procedure, was originally worked out by Lexer. He has demonstrated the first successful result, in a case where he padded out a sunken cheek with fat, following fracture of the angle of the jaw, three years after operation.

Rehn arrives at the following conclusions regarding the histology of the fat flaps transplanted by homoplasty and autoplasty:

After autoplasty part of the transplanted fat tissue remains unaltered; in the remainder, changes as found in homoplasty are observed. In spite of pressure atrophy, cell infiltration, and cystic degeneration, the embryonic fat cells, some arising from the older fat cells, others attached to the connective-tissue fibres, emerge as victors and regenerate. In homoplasty this process is exceedingly long drawn out. While there appears, after fifteen days, vigorous fat tissue in autoplasty, in homoplasty the constructive and regenerative processes are still in their infancy.

One takes the flap or pad of fat to be transplanted together with the subcutaneous tissue, being careful not to squeeze or tear it, and

implants it in the previously prepared wound, in which there is complete hæmostasis. And if the rule is followed that the transplant does not lie directly under the suture line, one can obtain excellent results, even when large flaps are transferred.

The clinical application has proved of value in numerous instances:

1. To pad out depressions of the face; for example, after comminuted fracture of the frontal bone, in which case an incision is made at the hair line, the skin is dissected away from the underlying scar tissue, and the fatty pad is inserted.

Defects after breast amputation can be likewise repaired provided the skin is in good condition. Filling out of the orbit after ocular enucleation has also been successfully performed.

2. Plugging up of bony cavities, the result of repeated operations for chronic inflammation, instead of leaving ugly bony packing, has been successfully accomplished by Chaput, Potherat, Makkus, and others. Hesse substantiates these good results. The implanted fat attaches itself to the fibrous tissue, which apparently is scattered throughout the bone. From my experience more rapid, more certain healing without sinuses occurs after this method than after the use of iodoform gauze packing.

3. To prevent adhesions: In this connection, from my own experiences, fat transplantation plays a very important rôle. Fat insertion to prevent rigidity of joint after operations for ankylosis succeeds with best results in the loose joints of the arm, although favorable results have also been obtained in the hip and knee (Murphy, Lexer, Röpke). In operations on the knee, fat pads prevented recurrence of fixation of the patella. Likewise, fat implantation on the freshened acetabulum has relieved the ankylosis of congenital dislocation of the hip due to hemorrhage (Lexer). What changes take place in the flap of fat introduced into the joints is not known. There was no sign of the oft-mentioned watery-like fluid. Whether or not it will make its appearance later I cannot say.

In progressive myositis ossificans, the only improvement I could obtain was increased range of motion by resection of the larger bony nodules and filling in the dead spaces with fat tissue.

I obtained marvellous success in protecting nerves and tendons by means of "areoloplasty" in preventing adhesion (Eden, Rhein). In this field the greatest successes have been achieved.

Extensive clinical investigations have demonstrated to me the value of fat implantation in brain surgery. In spite of the numerous plastic materials that have been tried to remedy dural defects, none serve so

well as fat tissue, especially when the pia is scarred, or is injured during the operation; or, when there exists also brain injury in the immediate vicinity of the dural defect. No graft, be it peritoneum, fascia, or fat tissue, can be implanted on the abnormal pia without the subsequent formation of adhesions or scar tissue. The transplant attaches itself to the injured pia, as it does on the bony side, but a thick flap of fat acts as a bolster and prevents the growth of tough, injurious scar tissue between the brain substance and the calvarium, at the same time effecting a complete closure of the subdural space (Rehn). This in my opinion places free fat transplantation for the repair of dural defects with co-existing brain injury or a pathological pia, as the method of choice before all other operative methods.

I have also had the experience to place a fat pad in a brain defect due to an open, dilated ventricle, closing the opening with a flap the size of a fruit plate. At the same sitting a skull defect was repaired with a bony graft, necessitating the healing together of two foreign tissues.

TRANSPLANTATION OF MUSCLE

Muscle is not favorable tissue to transplant by autoplasty, since it soon deteriorates because of insufficient nutrition. Even if, following the suggestion of Jores, the muscle is frequently stimulated by faradism, the end result is cicatrization because of the absence of the necessary nerve attachments. Success is not constant, even if the muscle be transplanted with its main nerve, so that it receives its impulses from the central nervous system. The possibility, however, of such transplantation was demonstrated by suturing the nerve to another nerve-trunk. The faradic current must be employed to exercise the functional powers, after such conductivity has been established.

Investigations by Wrede and Stiassing along these lines yielded negative results, while Göbel ascribes success to stimulation of the regenerative powers of the defective tissue rather than to the transplant.

It is very convenient at times, when there is a scarcity of fat tissue, to utilize pieces of muscle for packing bone cavities. Implantation is attended with as little irritation as when fat is employed.

NERVE TRANSPLANTATION

The reasons submitted as against the successful transplantation of muscle hold good for successful nerve transplantation. Transplantation of nerves can be utilized for bridging over defects, and they act

as do other tissues used for the same purpose, as, for example, segments of fresh veins, but there appears to be no advantage in using them. In order that other nerves are not injured, homo- or heteroplasty must be practised. Noteworthy reports have been recorded by Durour in heteroplasty.

Practically, we can in many cases of injured parts of muscles or where muscles as a whole have been destroyed, make use of transplantation by means of a pedicle, and, in the case of nerve defects, of other tissues as above mentioned. In those instances where entire muscle groups and nerves have been destroyed, muscle transplantation would be the ideal method of repair.

VESSEL TRANSPLANTATION.

Vessel transplantation has been made possible by the perfection of the blood-vessel suture (Carrel, Stich).

The first attempt was made by myself in 1907, when I resected an aneurism of the axillary artery and set in a section of the saphenous vein. The operation in itself is not difficult, but great care must be exercised in handling the graft, as the slightest injury predisposes to thrombosis.

Indications for vessel transplantation in arterial defects occur after resection for aneurism, removal of large arteries with tumor masses, especially where it is imperative that the circulation must be maintained. This is always the case when there are present conditions which militate against the establishment of collateral circulation, as arteriosclerosis, hemorrhagic infiltration, and cicatrization. Since autoplasty here deserves precedence, and one cannot employ the segments of other arteries of the patient, the saphenous veins must supply the grafts. The dangers attending ligation of the arteries of the arm or leg or common carotid will be minimized, in a certain percentage of cases, where there are present hindrances to the establishment of collateral circulation, if the surgeon can attempt to replace the arterial segment with one of vein.

The value of vessel homoplasty lies in the fact that healing and replacement take place only from the inherent blood-vessels and connective tissue. Thrombosis is of frequent occurrence. With heteroplasty no better results have been obtained.

Vessel transplantation is applicable for:

1. Replacement of arterial deficiencies as described.

2. Attempts have been made to repair congenital and acquired defects of the urethra by insertion of segments of fresh saphenous

vein. The results varied, due partly to unsatisfactory hæmostasis, and partly to coincident inflammation. It is not necessary to divert the urinary flow by means of cystostomy, as when an appendiceal graft is employed. Possibly this is due to the early adhesion of the adventitia to the walls of the wound. Constriction does not always follow, due to contraction and narrowing, and can be prevented by the use of sounds. Occasionally a mucous membrane covering is provided by the mucosa of the urethra.

3. Repair of ureteral and gall-duct injuries have been attempted by Makkas, Tietze, and Floercken without great success. Failure has been due to immediate utilization of the tube for urinary or biliary flow, which could be prevented only by nephrotomy or drainage.

4. Vessel transplantation is of value to bridge over defects of tendons or nerves. In the latter instance it is of the greatest value even in homoplasty, while I have long since abandoned insertion of vein or artery segments in the former, since free tendon grafts yield far better results and are more serviceable.

5. Henle and Payr have made use of vessel segments as drainage tubes in hydrocephalus, to direct the ventricular secretion into the venous circulation.

6. Koenig used fresh pieces of vein to protect uncertain suture lines, as, for example, in the urethra.

TENDON TRANSPLANTATION

The thought that tendons are amenable to transplantation by auto- and homoplasty occurred to me in 1907, when I noted how well they healed after my first knee-joint transplantation. This served as a stimulus to undertake the clinical and experimental investigation of tendon transplantation. The conclusions of my assistant, Ed. Rehn, which are of importance, follow:

The implanted segment of tendon heals,—even in homoplasty,—but marked differences in its properties are noted, dependent upon whether the part is immobilized or early motion is permitted. In the former case, adhesions occur, the segment is invaded by fibrous and scar tissue, so that it is tightly bound down, while early stimulation by motion results in the growth of a strong tendon, and regeneration is aided by the early appearance of blood-vessels along the suture lines. In no other part of the body does early functional stimulation play so important a rôle.

As the result of my clinical experiences, application of tendon transplantation is feasible in the following:

1. In the repair of torn ligaments, autoplastic and homoplastic insertion of tendons is attended by success, as, for example, in the patellar ligament, deltoid ligament accompanied by fracture, while repair of ventral hernia is possible if the fibres are laid in the same direction as the original tissue.

2. Tendons can be substituted for muscles for the cure of paralysis, or tendons can be replaced or strengthened in this way, or especially in defects of the tendons due to neglect, misplaced sutures, or where suppuration with necrosis of the tendon sheath has occurred. In these cases autoplasty with fresh tendon segments gives natural and most favorable grafts. These operations must be followed by passive motion.

Healing with resultant motion is attained by tunnelling out the wound, removing only small sections at a time, in order that the insert be not covered by a long suture line and consequent long scar.

My experience has been as follows:

If the tendon defect in the finger is covered by a large long scar, as is usually found after abscess of the tendon sheath, the adherent tendon must be liberated, and the cicatricial tissue must be removed down to the bone and capsules of the joints, after which the whole wound is covered with a pedunculated or free skin flap. This is then followed by the tunnelling above mentioned. If there is present deformity of the finger, due to suppurative necrosis of the flexor tendons, a small oblique incision is made over the inner side of the palm, down to the adherent tendons, and the latter are freed from the scar tissue and stretched. The skin is then raised by means of an elevator to the tips of the fingers while they are held extended. After the tendon graft has been firmly sutured to the flexor profundus tendons it is guided through the canal with a small sound to the finger tips and there sutured to the subcutaneous fat close to the bone. In order to obtain an ideal result, so that the graft is attached to both phalangeal joints, another segment is sewed to the stump, and guided through the canal to the middle phalanx, where two small lateral incisions are made and the distal extremity is sutured deeply, under protection of the nerves and vessels.

It is a simpler matter to implant the extensor tendons. Where multiple tendons are to be repaired, it is necessary to build up a skin flap. If primary union occurs within a week, active and passive motion is instituted and continued as long as is necessary.

After mobility has been obtained after transplantation of the flexor tendons, one can apply transverse bands about the joints to hold the tendons in place, or a like result can be accomplished by having the

patient wear a ring, so that when an object is grasped it presses against the ring (Rehn). In this way the profundus is brought into action strongly. A procedure that yields good results is a transverse bridging of the skin over the median joint, *i.e.*, two long pedunculated skin strips are placed crosswise over the joint. The scar between the flaps should lie immediately over the normal skin fold of the joint. This bridging acts just as does the transverse band, in that it allows bending of the tendons. In cases where there existed no previous ankylosis, or where the bones had not suffered extensive injury, we were rewarded with satisfactory results (Rehn). When ankylosis of the phalangeal joints is present, it must be remedied by insertions of fatty flaps before the tendon repair is begun.

Tendon transplantation is also of value for lengthening tendons, where muscular deformity has occurred as the result of contraction, as after ischæmic paralysis in the forearm. After the tendons have been divided, and the deformity of the fingers has been corrected, insertions are made into the defective flexors. In children with thin tendons, I lengthen the tendons by a Z-shaped incision.

The source of the material for this form of transplantation is easily accessible, but not always available. One can remove without harm the tendons of the palmaris longus by making two small tenotomy incisions. Also, the extensor tendons of three to five toes can be utilized without disturbance to the function of the foot.

Tendon homoplasty is apt to cause adhesions because of the irritation of the foreign tissue, for which reason it is more useful in the repair of ligaments than for freely movable tendons.

FASCIA TRANSPLANTATION

Fascia transplantation is similar to tendon transplantation. To Kirchner belongs the credit of the original experimentation and clinical proofs in this field. The indications are numerous: repair and strengthening of ligaments and capsules of joints; repair of tendons and dura mater; reinforcement of suture lines as in large hernia (Könog, Hohmeier); building up of aponeuroses for the transfer of muscle function, as in the frontal muscles for ptosis; application of fascial flaps between articular surfaces after post-operative injury to the synovial membrane; in mobilization of joints; as a base for hæmostatic sutures in organs; suspension of the pylorus at the site of excision (Wilms). Attempts have been made to utilize fascial flaps for large defects of the pleura, the diaphragm, or trachea. They are not of practical value for the replacement of tendon or nerve sheaths, since dense adhesions are formed (Goldmann).

The source of the material is the fascia lata, with its strong fibres from the outer side of the thigh. Homoplasty carries no advantage over autoplasty, because of the availability of the material. According to Rehn's experiments on animals it is practically possible.

PERIOSTEAL TRANSPLANTATION

In 1859 Ollier attempted periosteal transplantation, and later investigators have confirmed Marshaud's findings, that periosteum belongs to that class of tissues which permit implantation, and that it pursues its function of bone production provided that the soft medullary tissue does not come in intimate contact with bone.

Its application is like that of fascia, exclusive of tendons and ligaments. Periosteal flaps inserted between torn synovial membranes of the elbow-joints have acted well, according to Hofmann. Fractures have been enveloped with periosteal flap to increase callus production.

Practically, autoplasty has been proved, and homoplasty is not far behind, since we know the bone producing property of periosteum that has been transplanted together with bone.

PERITONEAL TRANSPLANTATION

I first attempted implantation of peritoneum for the repair of a dural defect, acting upon a suggestion from Kocher. Normal peritoneum was not used, as a hernial sac and a hydrocele sac were at hand. Adhesions resulted, just as they did in attempting to build up a new capsule about a knee-joint. According to Drandt, the use of peritoneum to repair dural defects with normal underlying pia, whether it was implanted on the inner side or the outer, or even if both layers were employed, resulted in the same way. Kolaczek, however, in implanted peritoneum over normal pia, noted few or no adhesions.

I question the value of repair of dural defects with peritoneum, fascia, or periosteum, since the underlying pia is usually injured, cicatrized, or necrosed, and dense adhesions follow between the skull and brain. For this reason, as above mentioned, I prefer the method of fat transplantation, since the graft acts as a pad and prevents areas of adhesions.

Transplanted omentum is liable to adhesion in the free peritoneal cavity, as shown by Springer. It, therefore, is an excellent material to use for the repair of injuries of the intestinal wall not accompanied by perforation or to strengthen the suture lines in gastric surgery (Sabaki).

BONE TRANSPLANTATION

In the art of transplantation, bone implantation is the most ancient; in point of knowledge and practical use, it is more important than even skin transplantation.

In the interesting history of bone transplantation, the following facts are worthy of mention: In 1809, Merrem obtained successful healing of bony plates in the skulls of animals after trephining. Later Walther, in applying these experiments to man, obtained partial healing in spite of coincident suppuration. Ollier then, in 1858, attempted with success bone transplantation in animals and in man and worked out its applicability.

The conclusions of Ollier consisted in the fact that fresh bony tissue covered with its periosteum remains viable, that denuded of periosteum it necroses and acts like a foreign body, becomes absorbed, and is replaced by bone only because of contact with the osteogenetic walls of the wound.

Dead bone, *i.e.*, macerated and boiled bone obtained from the cadaver, or fresh bone which has been sterilized, lends itself to transplantation, but it acts as does a foreign body, which slowly undergoes substitution; it is rapidly destroyed by vigorous granulations, by means of a "gnawing" process. Foreign body suppuration with extrusion of the dead graft, long after primary union, occasionally occurs. Likewise bone transplanted from animals, as, for example, that of the dog, is tolerated by man. Küttner obtained good results only with bone of the ape. I obtained union of segments of long bones, *i.e.*, in the defective bone, only when the periosteum of the recipient was intact. Homoplastic and autoplastic transplanted bone will heal without partial absorption only when the fresh graft is transferred with its medulla and periosteum.

The function of the graft and its covering lies in the fact that it replaces the missing tissue and enables the body to build up new bone. For this purpose the transplant is endowed with long life and vigorous powers of regeneration, and the implanted graft retains its shape until the edges of the recipient's defective bone regenerate, in spite of the fact that the implanted bony tissue disintegrates and becomes necrotic, as Marchaud, Barth, and others have established.

A further advantage in including periosteum is that it aids in the cementing of the graft to the wound edges and stimulates invasion by blood-vessels, thus establishing early nourishment.

These clinical conclusions have been substantiated in many respects by histological investigations. Barth recognized the fact that

included periosteum plays an important rôle in transplantation, and later experiments by Axhausen, Frangenhein, and others have demonstrated positive proofs in this respect.

As Ollier has shown, the best material to use for bone transplantation is the bony tissue, including the medulla and periosteum. Autoplasty, concluding from our experiences, is the method of choice, and one does not find any difference whether the graft is implanted as one piece or in fragments. Necessary substitution can take place only through the agency of the implanted elements of the periosteal and medullary layers. In fragments of bone transplanted by autoplasty this occurs in a lessened degree. Petroff, experimentally, found a distinct difference in homoplasty and autoplasty in that substitution took twice as long in the former. It is certain that the best form of healing, together with survival of the bony tissue, with slow absorption and equal regeneration by means of the inherent elements of the graft, occurs usually with autoplasty; and, furthermore, that the application of large denuded (of periosteum) living pieces of bone—equally in auto-, homo- and heteroplasty, or with the use of dead bone—when imbedded in bare (not covered with periosteum) spaces, is accompanied by so rapid an absorption that substitution cannot keep pace with it, so that the continuity of the entire piece becomes broken.

Clinical success, therefore, in the repair of large denuded bony cavities, can be achieved only by the use of living bone covered with periosteum. Should, however, the periosteum of the recipient be intact, it is immaterial what method of transplantation is employed, as the respective graft heals as does a foreign body, and is soon replaced by the periosteum of the defective bone, in fact often thickened.

In spite of this, preference should always be given to the living homologous bone, as the foreign body, which irritates the periosteum and thus stimulates its bone formative processes, otherwise soon disintegrates. By autoplasty skull defects can be repaired, with periosteum covered plates obtained from the outer table nearby (repair of skull defects, Lexer). In children, where the skull is so thin that even pedunculated, skin-covered flaps cannot be removed, periosteal bony flaps may be transferred from the tibia. Röpke suggested resection of a portion of the scapula for the repair of skull defects, in order that the graft be covered by periosteum on both surfaces. For smaller defects, those concerning the small bones, as, for example, of the carpi, or for the repair of saddle nose, rib resection can be performed. The fibula yields good fragments without periosteum. Large, broad fragments can be obtained from the anterior portion of the tibia: the cavity

naturally healing from the medulla (Bier). Entire phalanges of the toes permit of transplantation into the fingers (see joint transplantation). Autoplastic material is scarce. In homoplasty use can be made of amputated limbs which are not the seat of inflammation or malignant growths (serious injuries, dry gangrene, dry diabetic gangrene).

The field of usefulness for free bone transplantation is large. Only the most important indications are mentioned.

1. Repair of cavities in the cranial bones. One or more segments of the external table covered with periosteum are transferred from the immediate neighborhood. The cortex of the tibia or a portion of the scapula also is available. In the latter, it is of advantage, as the fragments are surrounded by periosteum.

2. Filling in of sunken spaces in the face. In saddle nose, in sunken spaces in the forehead following operation, or in bony defects due to tuberculous osteitis of the facial bones, in recession of the superior maxilla due to hare-lip, after the soft parts are raised, small fragments of bone may be imbedded.

Bony plates may be imbedded in the skin of the arm, later to be transferred for the repair of nasal and facial defects, as recommended by the Italians.

3. Repair of defects of long bones and the inferior maxilla. In the long bones, even when the periosteum is destroyed, large defects can be repaired, coincident with amputation. Only one needs fresh amputation material in order to obtain bone of sufficient thickness. Since such extensive defects are, as a rule, the result of operative interferences for centrally situated sarcoma, successful repair does not always follow. If a graft is not at hand, contraction of the defect can be prevented by the insertion of pieces of ivory or horn, and later fresh periosteum covered fragments can be substituted.

Where the above substitute is not used, and contraction of the soft parts occurs on account of bands, care must be observed that cicatrization is prevented in the wound intended for the transplant, since, owing to the deficiency of blood-vessels, nutrition is interfered with. Cicatricial tissue also prevents the formation of a strong callus on the part of the recipient, as it is necessary that vigorous growth occur into the graft. In defects of the long bones, long pieces of thin transplant (fibula or femur) have been utilized, being selected because of the functional obligation of the limb to carry the weight of the body. In the arm, on the other hand, thicker segments are indicated, since they become thinner and disappear. For this reason, in defects of the long bones of the arm where the periosteum is wanting, very thick fragments

should be imbedded. For the shorter bones, where defects, as a rule, are due to tuberculosis or suppuration after injury, pieces of rib or fragments of the tibia (mostly autoplastic) are useful.

In repair of the inferior maxilla, free bone transplantation is applicable, but one has to deal with intercurrent infection of the wound from the oral cavity. In 1908, I recommended the trial of transplanted fragments of ribs covered with periosteum, by homoplasty. Several authors (Goebell, Dumont) later reported successful results by using rib segments or clasps of tibial fragments. Secondary imbedding in the resection wound is naturally less prone to the danger of infection than primary. However, on account of the situation of the lower jaw, the latter is more imperative.

4. Fastening of bony fragments. Fresh fragments of bone, particularly of tibia covered with periosteum from amputated limbs, or costal or tibial segments from the same patient, have been used by Lexer to fasten the fragments of old or recent fractures, especially of the neck of the femur. One-half of the length of the transplant is forced into the medullary cavity of one fragment, the remainder into the medulla of the other fragment, of the fractured bone. Should insertion into the latter be difficult, the medulla can be enlarged by splitting the shaft beneath the periosteum. This "bone bolting" is useful in immobilization of the ankle-joint of the paralytic foot (Lexer); a canal being bored from the heel, through the os calcis, and astragalus to the lower end of the tibia. This canal should not be made too wide, as the bolt must be inserted forcibly so that blood and detached marrow cannot collect between it and the bone, since bone will unite with the surrounding bony tissue only when it lies in intimate contact with it, otherwise granulations appear in the walls of the canal, interfere with nutrition and predispose to rapid absorption. Some of the failures reported by authors are due to this technical error. It is a strange fact that this bolt stimulates thickening of the spongy portion of the bone, while it is absorbed in the upper ankle. Therefore ossification rarely takes place in this joint, as a rule, only the necessary immobilization. This procedure is simpler than the usual arthroplasty, and with proper care yields satisfactory and permanent results. Bony bolts can be used in the place of nails to fasten bones, as after the resection of joints.

Other applications of bone transplantation are the replanting of dislocated bony splinters, which must be removed on account of severe injury or pressure on nerves or vessels. It has been attempted (Albee) to repair vertebræ, the seat of tuberculosis, by imbedding plates of tibia, or to fasten the vertebral joints after dislocation through the medium

of pieces of the spine of the scapula (De Quervain). Recently, Perthes reported the successful cure of flat-foot by means of bone transplantation. The inner border of the foot is shortened by removing a section of the navicularis. Osteotomy of the os calcis is done and the outer border of the foot is lengthened by driving the fragment of the navicularis into the incision in the os calcis.

CARTILAGE TRANSPLANTATION

According to Marchaud, in cartilage transplantation the perichondrium plays the same part that the periosteum does in bone or the tendon sheaths in tendon transplantation, since it favors regeneration of the parts that tend to disintegrate. Repair can also occur, as shown by Axhausen, by reproduction of the living cartilaginous cells, so that successful transplantation of cartilage does not depend entirely upon the presence of perichondrium; a fact that has an important bearing on the satisfactory outcome of implantation of articular cartilage.

Since cartilage from the ribs is so easily available, it is, as a rule, unnecessary to resort to homoplasty, although it yields good results.

Cartilage transplantation can be utilized for filling out sunken areas on the face; or for imbedding between the torn layers of the synovial membranes of the smaller joints, when other tissues, like fat, are not available. For nasal repair, a small piece of costal cartilage forms a good tip. A sunken tip can be raised by the insertion of cartilage into the septum. In the repair of saddle nose, fragments of cartilage have the preference over bony segments, as they can be more easily fitted. One may substitute pieces of cartilage for bone in the repair of phalanges, carpal or tarsal bones.

The advantage of cartilaginous union over that of bony is problematical, since its properties, regarding durability and usefulness, are the same as those of periosteum and osseous tissue. This fact is of the greatest importance in determining the future growth of transplanted (homoplastic) joints during the growing age (children). Experimental evidence leads to varied conclusions (Helferich, Enderlen, Rehn, Borst, Heller, von Tappeiner). The majority found more or less necrosis at the site of the union, with disturbance of the reproductive processes (in homoplasty). Heller found the greatest interference in homoplasty, less in autoplasty. Rehn obtained very favorable results. He transplanted by homoplasty the radial epiphyses of young guinea-pigs of the same brood, and demonstrated the endurance and the reproductive powers of the cartilaginous border.

Even though the majority of investigators rule against the practical

application of cartilage transplantation, Küttner was able to perform heteroplasty by transferring the fibula of an ape into a child, which one and one-half years later, under X-ray, showed complete viability of the epiphyseal line. In one case, in whom I performed homoplasty (repair of an ulna by means of the shortened fibula of an older child) two years after showed by X-ray adhesion of both cartilaginous areas, but disturbance of growth was not noted, although the central portion of the bone was completely absorbed.

Saer has accomplished recently, by means of autoplasty, substitution of the head of the fibula for a severely injured distal extremity of the radius in a child. This procedure is rather too recent to be commented upon.

No definite opinion can be given regarding the ultimate applicability of implantation of cartilage, because the number of operated cases have been small, and have not been observed for a sufficient length of time, and animal experimentation has given rise to varied results. At any rate one is dealing with a very susceptible tissue, since the slightest interference with nutrition disturbs its growth.

JOINT TRANSPLANTATION

Joint transplantation is the outcome of the work done with cartilage and bone transplantation. It necessarily follows that if one can perform homoplasty with large segments of the long bones, it is possible to transplant the bone with its articular surfaces.

The earliest experiment in this field was attempted in November, 1907. It occurred in a case of defect in the tibia involving the entire upper third of the tibia, including the articular surface, due to a central sarcoma. The former procedure in like cases was to engage the lower end of the femur into the tibia by boring, thus permitting of union between the bones with considerable shortening of the limb. In order to obviate the latter result, and, if possible, to restore the mobile functions of the joint, a similar portion of tibia was removed from a freshly amputated limb and implanted with its articular cartilage and periosteum.

Then the thought arose to advance a step further. If it were possible to achieve healing of this large segment of bone with its articular extremity, like success might be attained by transplanting the articular surfaces for the repair of joints.

This idea I carried into play on the same day, as I had at hand a freshly amputated limb, and had on numerous occasions attempted to use other tissues and, lately, fat, to mobilize joints. After resection

of the synovial sac, the articular surfaces of the tibia and femur, with their attachments the crucial ligaments and the meniscus cartilages, together with the cartilaginous fragments of thumb thickness were dissected and implanted in their entirety over the previously prepared defect. The first method I called half transplantation and the second whole joint transplantation.

By half joint transplantation, I implied transplantation of bony extremities, utilizing their articular membranes as much as possible, while in whole joint transplantation I attempted imbedding of long bones with both articular surfaces. This work was successfully carried out by others (Küttner, Rovsing, Wolff, Enderlen, etc.) as well as by myself.

The source of the material has been freshly amputated limbs. I have discarded the use of material from the fresh cadaver, first, because of the difficulty in obtaining sterile tissues from the morgue, and second, because fibrous encapsulation took place in one case of knee transplantation. It is another matter to utilize a limb or segment of bone from one who has met his death by injury, provided all the rules of asepsis are observed.

Küttner has further worked out the utilization of the fresh cadaver, and reports successes in half transplantation. This author employed homoplastic material under great difficulties, and in fact performed heteroplasty with tissues in which the albumen is closely related to that of man, *i.e.*, from the ape.

Autoplasty is applicable only to the finger-joints, as the toes can be substituted for them. Shortly after my first report, Buchman reported transplantation of the toe-joint into the elbow, after having arrived at the same conclusions as I had. Judet coincidently demonstrated limb transplantation in animals. Two specimens, the first being removed because the patient objected to the idea of carrying about the bone of another individual, the second because of the incidence of sarcoma, on examination showed the following changes:

The upper third of the tibia, implanted one and one-half years ago, which was healed into the knee with excellent functional results, showed spots of cartilage which had been isolated by areas of necrosis. The periosteum of the implanted fragment is thickened, and the fragment is firmly united to the bone of the recipient by callus. Osteogenesis is demonstrable from the periosteum. The cortex as well as the ramifications of the spongy layer is necrotic; at the site of the medulla there is present in the canals of the spongiosa fresh fibrous tissue, in the interstices of which there is bone regeneration. The articular cartilage

is in most part well preserved. The menisci are adherent to the capsule, as is the recipient's patella to the implanted tibial fragment.

The findings in the second case are similar five months after implantation of the lower end of the femur, except that there is present a spontaneous fracture due to the sarcoma.

The relation of the firm union of muscle, tendon, and ligament with the graft to restoration was noteworthy in these specimens, as well as in those of Küttner. Clinically, there were no unfavorable sequelæ, excepting a fluid exudate in the knee of my first case. The limbs were soon endowed with normal function, the leg was useful in walking and standing without aid. X-ray after two to three years showed irregularities in the borders of the implanted grafts, exactly like the deformities of arthritis deformans.

Naturally, the long bones can be transplanted in their entirety with both articular surfaces. This does not as yet pertain to the large bones as it does to the smaller ones. After injury of a phalanx with loss of function it formerly was the custom to amputate, as it interfered with the other fingers. Now, one is able to obtain a phalanx from an amputated limb, as I first showed in 1907, or autoplasty can be done by removing a toe, or a segment of rib cartilage, or other fragments can be utilized. Others (Wolff, Sievers and Goebell) also report successful work in this field.

Finally, half transplantation is useful in replanting injured parts of joints after luxation-fractures, as of the head of the humerus, part of the lower extremity of the humerus (Lexer, Perthes, von Haberer). Here the favorable wound bed plays an important part, as hemorrhage, infiltration, necrosis and cicatrization prevent the rapid establishment of sufficient nutrition.

In whole joint transplantation, where both opposing articular surfaces are transplanted, it follows naturally, that the articular cartilage must lie within the capsule of the joint. It was therefore feared that fibrous tissue would originate from the surrounding tissue, invade the joint cleft, destroy the cartilage and hinder mobility. On account of this fact, I attempted in the first case after healing of the joint, to implant fresh hydrocele sac to act as the articular capsule. Of course, induration occurred about the graft, but as shown after re-operation, this in itself acted as a sort of capsule, and prevented invasion of the joint cleft by scar tissue.

Up to the present time progress in whole joint transplantation has been limited to the knee-joint. From a clinical stand-point, I can testify to complete healing in a knee-joint, six years after transplantation.

The X-ray shows transformation partially by means of absorption, and partially by means of excessive growth at the site of union, similar to the changes occurring in arthritis deformans, but motion and function are perfectly free and satisfactory.

The joints are useful, because change in shape in this abnormal situation is prevented on account of its pre-existing form, and because mobility of the leg aids in this prevention.

The mechanism of the new knee-joint is in no way normal, since there occurs no rotation on the condyles. In a normal sense, there is present a pseudo-arthrosis, in which there occurs anterior gaping on motion. For this reason, I remove an elliptical segment of the thigh, and place on this the rounded portion of the stump of the femur. Thus, the patellar fascia of the transplant is anterior to the circumference of the condyles. This case, however, in spite of faultless healing and function, is of too recent occurrence to base any opinion on its permanence.

The greatest difficulty following fortunate implantation lies in the restoration of the severely injured extensor muscles, which with the tendons are occasionally destroyed by intercurrent suppuration, or which because of long standing ankylosis have become atrophic and fatty.

For this reason motion may be only passive, or flexion and extension may be restricted. Where the musculature is well preserved function is naturally more satisfactory than where operations are necessary to first restore the possibility of active motion.

Following the transplantation of both raw joint surfaces successful healing occurs, and if the graft is properly fitted material capable of substitution is deposited. The implanted portions grow according to their inherent abilities, and the substituted material is not subjected to stiffening or shrinking, this fact being in line with animal experimentation.

All ankylosed joints are not equally suitable for transplantation. Those after resection for tuberculous arthritis are subject to suppuration, because of remaining tuberculous foci, or due to weakening and cicatrization of the tissues about the transplanted material.

Knee-joints, the site of transverse scars, exerting traction on the resection line, are unsuitable for transplantation.

Toe-joints only can be used for finger-joint transplantation by autoplasty. One can even attempt transplantation of the capsule in this instance (Göbell), a method which resulted as a failure in my hands with homoplasty.

FREE TRANSPLANTATION

Satisfactory material for transplantation is difficult to obtain, since the limbs of elderly individuals are the seat of atrophic fatty changes in the cartilages, or the more or less crippled joints are of low vitality and have poor regenerative qualities, being subject to rapid absorption and complete necrosis. These difficulties are the exception in total joint transplantation, since under favorable circumstances satisfactory results are obtained.

I have established the fact that good results can be obtained in restricted joints, by freeing the articular adhesions and implanting fat, fascia, periosteum or muscle. In the after-treatment, because of the tendency to contraction, one must institute early passive motion, while during the operation, care must be observed to prevent recurrence of stiffening, by means of sufficient articular separation. The latter, again, may be followed by abnormal lateral mobility.

Experimentally, it is extremely difficult to perform joint transplantation upon small animals, since the transplant is readily injured by handling, and especially because complete hæmostasis is difficult The experiments of Judet, Wrede, Dalla Vedove, Duguing, Borst for this reason are unsatisfactory.

One cannot draw any conclusions on account of the difficulty of transplantation in small animals, from the occurrence of the total necrosis that is found. These failures demonstrated one fact, that success does not depend necessarily on the survival of the transplant. It has been shown in animals (Wrede, Judet, Axhausen, Rehn) and in man (Lexer, Küttner) in support of this fact, the successful transplantation of bone and cartilage, and in the latter, preservation of cartilage, periosteum and bone marrow with osteogenesis. Of clinical importance is the property of substitution as established by Borst.

TOTAL LIMB TRANSPLANTATION

Transplantation of fresh limbs *en masse* has been attempted from various points of view, but up to the present time autoplasty only has yielded results, *i.e.*, replanting of an amputated limb (Carrel and Jianu in dogs, Jianu in man, in whom there was not complete separation, in that the skin and veins remained uninjured).

The question of replantation of divided limbs comes up after severe accidents, but naturally, when the tissues are not macerated. Whether or not it is possible to replace an amputated limb by homoplasty, using one from the cadaver, remains to be seen. Until the outcome of this speculation is decided, it will be interesting to follow homoplastic limb

transplantation in animals and to note the effect of the foreign blood circulating in the grafted tissues.

Animal experimentation so far, along these lines (Carrel, Lexer) has been devoid of success, and promises practically nothing, since, besides ischæmic inflammation and contraction, it is followed by hemorrhagic infiltration and nerve disintegration.

ORGAN TRANSPLANTATION

The large domain of organ transplantation, unfortunately, has not as yet won practical recognition in spite of the hope that the possibility had been realized that entire organs could be transplanted through the medium of the main artery and vein with the respective vessels of the recipient (Carrel, Stich). Borst and Enderlen have established the fact that only those organs are preserved which have been removed from an animal and replanted into the same animal shortly after. Our knowledge of to-day emphasizes the difficulties of homoplasty in general, in that the highly differentiated tissue of organs always disintegrated.

Likewise the idea of Sauerbruch, of parabiosis (union of two similar animals by means of arterial and venous anastomosis) in order to mix the bloods, and thus to supply the homoplastic implanted organ in the recipient, with the nutritive substances of the donor, has as yet not yielded results (Enderlen). And if these difficulties were surmounted, and the homoplasty were successful, could one expect permanent continuance of function, when innervation of the glands is absent?

Only the organs with internal secretions, the ductless glands, functionated after transplantation (epithelial cells, ovaries, thyroid gland). But function did not persist, it is to be regretted, in that it remained only so long as the important substances were secreted from the slowly disappearing grafts. Experimental investigations have conclusively demonstrated in these cases disappearance of the transplant.

The clinician will be wise not to count upon prematurely awakened hopes for some time to come. It is possible that the outlook in homoplasty may be improved in one way or another, as has occurred in skin transplantation, and that it may bring us near the goal.

TISSUE AND ORGAN TRANSPLANTATION*

By Dr. Emerich Ullman
of Vienna

If one removes a portion of tissue from the body, it does not die at once, it retains its viability for a variable length of time. The viability of this removed tissue varies according to the nature of the source and the type of the tissue, the duration of its life depends upon its environment, as the temperature, etc. Plant grafts survive their removal for a long period of time; animal tissues a shorter period, and tissue from the more highly differentiated and organized animals dies sooner than that from the lower species.

Should the removed portion of tissue be replanted into the body from which it was taken, regardless of whether it is replaced on the same site or in a more remote location, it is called autoplastic transplantation. If the tissue is planted into an individual of a like species, it is termed homoplastic transplantation; if into one of another species, heteroplastic transplantation has been performed. On the other hand, grafting of tissues from the cadaver or of dead tissues is known as implantation.

Tissue transplantation has been employed for a long time, but organ transplantation has been made possible only during the last fifteen years, coincident with improved operative technic, namely, the perfection of the blood-vessel suture.

(The author then covers the ground of skin, mucous membrane, subcutaneous tissue, fat, muscle, bone, epiphyseal cartilage and joint transplantation. This portion is omitted since these subjects are also fully treated in the paper of Prof. Lexer, to which reference should be made.)

Blood-Vessel Transplantation.—After the failures of Glück, Exner and Höphner, Carrel and Mosel first were able to transplant veins into arteries. Carrel and Guthrie both made the observation that the vein becomes wider and the walls accommodate themselves to the increased pressure. Since then, due to the investigations of Borst, Enderlen and Stich (with an observation extending over 409 days) the possibility of autoplastic vein transplantation into arteries has been realized.

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*Read before the International Society of Surgery, April 15, 1914. Translated from the German by Dr. Max Lederer.

Autoplastic insertion of an arterial segment into a vein was followed by thrombosis, in the hands of Borst and Enderlen when performed on a dog.

Homoplastic transplantation of artery to artery was first attempted by Höphner by planting the femoral artery into a resected carotid, and pulsation was demonstrated 45 days later, when the artery was exposed to view. This was done on dogs. Carrel, Stich and others also report good results. Microscopical examination of a case of Borst and Enderlen showed that growth over the suture line arose only from the intima and the connective tissue of the carotid stump of the recipient.

In man, Delbet attempted the above procedure. He wished to repair a defect, eight centimetres in length, of the femoral artery after extirpation of an aneurism, with a piece of femoral artery obtained from a coincident amputation of the thigh. As the artery of the donor was sclerotic, he was compelled to desist, and content himself with ligation of the femoral, because the sutures would not hold.

The first to attempt heteroplastic blood-vessel transplantation was Höphner, who transplanted the aorta of rabbits and cats into the femoral artery of the dog. Hemorrhage or thrombosis followed. These experiments were repeated by Stich in the clinic of Garre; in spite of the theory of Payr, vessel sutures were employed. The first attempt resulted in an astonishing success, following implantation of a cat's aorta in place of four centimetres of a resected carotid of the dog in which autopsy *in vivo* after fifteen days demonstrated pulsation as in a normal artery. Further transplantation of cat's and rabbit's aortas into the resected carotid of the dog after 51 and 52 days, was attended with good healing and function. A segment five centimetres long of the posterior tibial artery, obtained from a freshly amputated leg of a man, was successfully transplanted into the carotid of a dog. The observation period was only fourteen days in this case. Of six heteroplastic transplantations, half were successful. These positive results were soon confirmed by Carrel. He transplanted the segments of the carotid or the jugular veins of dogs into the resected aorta of cats. In three out of five cases the suture lines broke down, while in the fourth case, six days after the above-mentioned extirpation, there was demonstrable functional result. In the fifth case, exploratory laparotomy showed good pulsation in the aorta and in the transplanted carotid segment, and 78 hours after the operation the condition of the animal was good and there was vigorous pulsation in both femoral arteries. Ward, also, sutured a piece of the aorta of a rabbit into the carotid of a dog; up to the seventieth day, the functional result was

good. Borst and Enderlen performed two heteroplastic transplantations from the cat to the dog and from the goat to the dog. In the first instance, examination 74 hours later demonstrated between the obliterated suture lines of the carotid stump a thin, smooth, light brown tissue strand. This was the remains of the completely absorbed implanted cat's aorta. In the second case, transplantation of the goat's carotid into the dog's carotid, the former after 87 days, was found thrombosed and obliterated.

When one examines the transplanted heteroplastic t sue which is functionally useful, it histologically is anything but normal. In Stich's specimens, the transplanted material was completely disintegrated, for in three weeks there was invasion by a rich cellular tissue derived from the vessel of the recipient into the human, cat, or sheep vessel, and in a shorter time the media was represented by rests lying as scattered areas of tissue in the newly formed scar tissue. Together with these changes, thrombus formation in the lumen of the vessel took place. In those parts of the vessel wall which remained free from these changes for a time and which retained their normal endothelial lining, sooner or later the greater portion of the intima became covered with fibrin, soon becoming organized and covered with fresh endothelial cells. Wood, after examining wax preparations under the microscope, found disappearance of the normal construction of the transplant with substitution of the vessel by fibrous tissues.

Material for transplantation was also obtained from the fresh cadaver. This was called by us implantation. Makkas, Dowman and Stich sutured into the circulatory system of animals, vessel segments obtained from animals killed with chloroform, the specimen being removed in from fifteen to ninety minutes after death and placed in physiological salt solution. Out of five attempts, three were successful while two were followed by fatal hemorrhage.

Carrel and Guthrie extirpated portions of vessels from living animals or from animals shortly before death, placed them in Locke's solution in a glass chamber, at from zero to one degree Centigrade, and preserved them for weeks under sterile conditions. Later these segments were grafted into animals (homoplasty) and good results were obtained even with tissues preserved for 35 days. Microscopic examination revealed extensive changes in the vessel walls.

Bode and Fabian preserved portions of vessels in Ringer's solution at from zero to one degree Centigrade for 60 days and implanted them in dogs, using the vessel suture. In the majority of instances, total thrombus formation occurred, while in the minority the lumina re-

mained patent. Bode and Fabian are of the opinion that after preservation of the segments for more than 35 days in the ice box, they become predisposed to injurious changes in the vessel, which they admit cannot be demonstrated microscopically.

Carrel performed heteroplastic implantation with segments of dog's carotid and jugular veins, which had been preserved in the ice box as long as three weeks and implanted into the resected aorta. The functional healing was apparently successful, although it could not be proved microscopically that the implanted vessel became part of the recipient's tissue. Carrel also performed implantation of a portion of the popliteal artery of a man, which had been preserved for 34 days in Locke's solution, into the aorta of a dog. Five and one-half months later autopsy *in vivo* demonstrated the implanted human popliteal artery in the same condition as during the implantation, and fourteen months later normal pulse beats were found in both femoral arteries. Guthrie also was able to successfully implant into a dog's artery a portion of cat's aorta which had been preserved for four weeks in formalin; and Bode and Fabian report implantation of human vessels into dog's arteries after preservation in the ice box. Regarding the changes which take place in veins after transplantation into arteries, Carrel states that first on account of the increased blood-pressure there occurs a hypertrophy of the walls followed later by a disappearance of the muscle bundles with sclerosis of the wall by means of infiltration with fibrous tissues. Whether or not there later occurred further changes in the vein is not known, but it is very probable.

Vessel transplantation, however, has been utilized for other purposes than for substitution of vessels. Eiselsberg reports a case of perineal hypospadias in which he utilized a portion of the saphenous vein as a substitute for the urethra, and almost complete healing was obtained one year after the successful transplantation. The sequel of this grafting is a strong tendency to shrinkage of the vein. Bakasch substituted in a case of scrotal hypospadias a portion of the basilic vein for the absent urethra with faultless healing, but he fears that this healing will not be permanent. Other surgeons also have substituted the saphenous vein for congenital and acquired defects of the urethra sometimes with, and sometimes without, success. The gradual disintegration of the vessel segment with subsequent cicatricial narrowing is due to the immediate flow of urine over the endothelium, as proved by Tietze, and Lexer has devised the operation and pleads for the production of a fistula over the implanted vascular tube.

Floercken attempted to plant segments of the carotid into the urethra and observed that the endothelium, even when autoplasty is performed, disintegrates, after which suppuration and necrosis of the wall takes place. Here, also, it is true that the immediate flow of urine causes irreparable injury to the endothelium. Vessels which have been utilized to repair gall-duct defects disintegrate probably because of contact with bile.

Ritter recommends in the repair of injuries of the tendons, where tendon suture is possible, but where the union is uncertain, the use of vascular tubes as shields into which the ends of the tendons lie.

Segments of vessels have been utilized with good results, especially autoplastic transplantation of the saphenous vein, as a bridge in the repair of nerves. Some surgeons have seen good results with homoplastic vessel transplantation for this purpose.

Heart.—Carrel and Guthrie have performed transplantation of the heart. They transplanted the heart of a small dog to the neck of a larger one and united the divided ends of the jugular vein and the carotid artery with the aorta and the pulmonary artery and the vena cava to the pulmonary vein. The transplanted heart after a short time again began to beat vigorously. At first the auricles, finally also the ventricles, began to beat at the rate of 88 to the minute, while the heart of the recipient beat 100 to the minute. Two hours later thrombosis set in so that the observation terminated.

The above authors also extirpated the heart with the aorta and vena cava and both lungs of a kitten one week old and planted them on the neck of a large adult cat. The aorta was united to the peripheral end of the carotid and the vena cava with the peripheral end of the jugular vein. Circulation in the coronary artery was established at once and the auricles began to beat. The lungs became red and in a few minutes visible pulsations of the ventricles set in. Dilatation of the right heart soon occurred because of the occurrence of œdema of the lungs. In two days the animal died of an abscess of the neck.

Thyroid Gland.—Shiff concerned himself with thyroid gland transplantation. He transplanted the thyroid of a dog into the peritoneal cavity of another dog. Some time after the transplantation the animals were killed and it was found that the transplanted glands either entirely disappeared or that only pale red vascular spots were visible at the site of transplantation. Histological examination of these vascularized areas was not undertaken. Thus homoplastic transplantation yielded negative results. Eiselsberg obtained successful results in experiments upon cats. He performed his operation in two steps, removing half of

the thyroid and planting it between the abdominal muscles and the peritoneum. As the second step, a number of weeks later he extirpated the other half of the gland. Tetany did not occur and only appeared when the transplanted and healed thyroid was subsequently removed. In Eiselsberg's researches, autoplastic transplantation of the thyroid only was considered. However, since in these researches the parathyroids were also transplanted the question remained open, whether or not the thyroid in itself functionated. At any rate, two observations speak in favor of the functional ability of the transplanted thyroid gland. First, as shown by Cristiani, that half of the thyroid when transplanted into the ear becomes larger when the other half is extirpated, and, second, the fact shown by Salzer of the rapid encapsulation and enlargement of the autoplastic transplanted half of the thyroid when the second half is removed at the same time.

The question as to where the thyroid should be transplanted, in the spleen after Payr, in the peritoneum, or in the bone marrow after Kocher, or in the subcutaneous cellular tissue after Cristiani, is as yet undecided. As a result of experimental investigation which was undertaken by Carraro, of Ribbert's Institute, it appears that the peritoneum or the subcutaneous cellular tissue hold the preference over all other tissues as implantation sites, while the bone marrow, spleen, and liver are entirely too vascular, since the transplanted portion of thyroid at first is always surrounded by a thick layer of fluid blood which forms a more or less thickened ring and later chokes the transplanted piece by means of cicatricial contraction. Bramann believes that this fear of Carraro's can be overcome in making use of the medullary cavity if one takes the precaution to curette out the marrow down to the compact bone and then to fit the transplanted piece so that very little blood can surround it.

The investigations of Stich and Makkas in autoplastic as well as in homoplastic transplantation of the thyroid, have been attended with marked advances in this field. Instead of bothering with circular sutures of a very small artery, they resected a rhomboid flap of the carotid and inserted it in the respective hole of the other carotid. Also the difficulties of vein implantation, which were greater than arterial implantation, were also fortunately overcome. Of the homoplastic transplantations, none was successful, while two out of three autoplastic transplantations were attended with success. One dog lived 31 days and the other 345 days after operation; they were lively and differed in no way, especially in intelligence, from normal dogs. The anatomically healed thyroid performed normal functions and proof of this was

shown when, after 245 days, extirpation of the healed thyroid was performed, after which the dog became ill and three weeks later he died of cachexia. Thyroid transplantation from man to man has yielded no results. The normal upper pole of the thyroid was transplanted in three cretins by suturing the superior thyroid, artery and vein to the axillary vessels. The grafts healed and after several weeks could be easily palpated, but later became gradually absorbed. The transplantation had no influence upon the intelligence or the growth of the animals.

Attempts at heteroplastic transplantation of the thyroid so far have been fruitless, as have been attempts to replant animal thyroids into man extra- or intraperitoneally, and when Kocher obtained improvements in a case of cachexia strumipriva after heteroplastic transplantation, it can be attributed to the subsequent absorption of the thyroid glands. (Beneficial effects being due to absorption of the thyroid secretion.—Translator's note.)

Parathyroids.—The first who transplanted the parathyroid was Waldbaum. He transplanted the external parathyroids autoplastically on to the peritoneum of the stomach and at the same time or at another sitting extirpated the internal parathyroids. He established, as a result of this experiment, that the external parathyroids could not maintain their function alone without aid from the internal ones, since the animals came to a cachectic end.

Kamus in 1905 transplanted by homoplasty the parathyroids from the rabbit into the ears of animals from whom he removed the parathyroids, as well as into animals who had not been so treated. The glands which had first healed finally completely disappeared. Cristiani, laying the cause of Kamus' failure to the fact that the ear of the rabbit was a poor bed for the implanted tissue, was able to microscopically demonstrate after autoplastic transplantation the parathyroids in the ears of cats five years later, and in rats two years later. In 1907 Biedel reported the successful autoplastic and homoplastic transplantation of parathyroids into the spleen of dogs and cats. In the same year Pool reported heteroplastic transplantation of parathyroids in which the rabbit was the donor and the dog the recipient. The external parathyroids of the rabbit were transplanted into the spleen of the dogs and the parathyroids of the latter removed. All the dogs developed tetany. Pool, therefore, discarded the heteroplastic transplantation of parathyroid and believes that even with a successful homoplastic transplantation one is not certain that the homoplastically transplanted parathyroids, even if they heal, are functionally valuable. Iselin is of the

same opinion, as the result of experiments with which parathyroids were transplanted into tetanic rats after parathyroid extirpation. Leischner reports successful autoplastic transplantation of parathyroids, and he also obtained healing in homoplastic transplantation, but in the latter instance, working with Kohler, he admits that the homotransplanted material is of little use, as the foreign tissue, after a short time, is absorbed. Shortly after Leischner's first work there appeared the conclusions of Minkiewitsch that all transplanted thyroids, whether by autoplasty or homoplasty, finally disintegrate even if they functionate for a short time, a fact which is not certain.

Pfeiffer and Mayer obtained a good functional result after autoplastic transplantation and healing of parathyroids. Hermann and Harvey confirmed these results with homoplasty, although success is not always certain. Melinkow reported like results and was able to prevent the development of cachexia. Landois performed transplantation of parathyroids in the dog, autoplastically and homoplastically by artificial emboli in the lumen of the external jugular vein, thus supplying nutrition to the tissue from the circulating blood, and at the same time providing a drain for the secretion of the transplanted organ. It was possible to cause healing with good function of the autoplastically transplanted parathyroids but the majority of the dogs died after a few weeks of inanition and hemorrhage without tetanic symptoms. Homoplastical transplantation of the parathyroids yielded bad results, the animals failing after operation or dying of tetany. Landois therefore concludes that homoplastic transplantation of parathyroids in man for therapeutic purposes is without hope.

Adrenals.—In 1887 Cannalis attempted implantation of small portions of the adrenal glands, without success, as the implanted pieces became necrotic and were absorbed. De Dominicis found in adrenals planted into dog's kidneys, no change after 10 to 15 days, and Pool in his work on rats noted that the medullary portion disintegrated, while the cortex regenerated. This fact was confirmed by Cristiani, and Stilling found in adrenals transplanted into the scrotum of rabbits that it contained typical cortical substance after three years. Monsen and LePlay transplanted the left adrenal into the spleen and after several weeks removed the right adrenal. Rabbits survived for three days, young dogs seven days. While the medulla disappeared rapidly, the cortex survived for a long time. Shiota transplanted the adrenal into the spleen and kidney. The animals survived. The transplanted adrenal loses its adrenalin content in 48 hours quicker in the spleen than in the kidneys. After 24 hours, there was no sign of medulla, while cortex

could be demonstrated 10 to 17 weeks later. The survival of the animals after later extirpation of the second adrenal proved the functional ability of the transplanted adrenal.

The adrenal transplantations of Habraro and Störck were successful. In one-half of their cases there was functional as well as anatomical permanent success. The failures can be accounted for by the insufficient nutrition of the transplanted organs. The microscopical examination of the transplanted and healed adrenal showed that in no case did the organ retain its original structure, but it underwent regressive and necrotic, as well as hypertrophic, changes. In the first few days after the transplantation there occurred regressive metamorphosis of the adrenal so severely that only those portions remained alive which were in contact with the vessels. At this site, there begins in the first few weeks after the operation, a vigorous parenchymatous activity which encroaches upon the degenerated portion of the organ. The hypertrophic tissue may later again regress or even become necrotic. The newly formed cell masses may take on the normal form of the adrenal, but there may be some irregularity not only in the cortex, but also in the ramifications of the medulla. In successful transplantation not only is the cortex preserved, which fact has been the basis of all investigations so far, but the medullary substance also remains alive and is able to regenerate and hypertrophy as well as the cortex. Permanent results five months after transplantation have been obtained, and in most cases a new adrenal was built up in which cortical and medullary substance replaced the regressive and necrotic tissue.

The functional proof of successful adrenal transplantation gave the following results: The unilateral transplantation was borne by all the animals (dogs, rabbits and cats) without ill effect. But one cannot say anything positive about the functions of the transplanted organ, since there is a possibility that this function was performed by the remaining adrenal. In a second series, both adrenals were transplanted into the kidney in two sittings with a considerable interval elapsing between the operations. If the second adrenal is transplanted, while the first is as yet in its atrophic and necrotic stage, no hypertrophy takes place and the animals die of adrenal insufficiency. The functional ability of a transplanted adrenal was proved by extirpating the second adrenal some time after the transplantation. In some cases in which there occurred necrosis of the transplanted adrenal the animals survived the second operation for a very short time only. In 9 cases, however, the animals survived the extirpation of the adrenal for a number of days and months. Microscopic examination here showed healing

accompanied by regeneration of the adrenal tissue with destruction of the vessels and revascularization from the kidney. Since there were no accessory adrenals in any of these animals, it follows that the transplanted tissue functionated. It was found here, as in bilateral transplantation, that the animals have a better chance for survival if there is an interval of from 11 to 16 days between the transplantation and extirpation, while a longer interval predisposes to failure. One gains the impression that the intact adrenal has so completely undertaken the function of the injured second organ that it hampers the latter's powers of regeneration. If the other adrenal is injured or removed, during the period when regeneration is at its height, a stimulus is given to the regenerating tissue. In a further series bilateral transplantation of both adrenals was done in two sittings and at a third sitting one kidney with its inlaid adrenal was removed. Out of 11 cases, 6 died of adrenal insufficiency. In all these animals the healed hypertrophic adrenal was accidentally extirpated, while the second on section showed regressive changes. Five dogs survived the operation for a year and a day without symptoms. The extirpated transplanted adrenal here also was hypertrophic. Incidental to homoplastic transplantation of the adrenal in man, von Haberer believes as a result of experiments on the cadaver, in the possibility of implanting into the aorta or femoral vein, the adrenals of dead new-born with its vessel and a piece of the aorta. Lately, Busch and Wright reported regarding heteroplastic adrenal transplantation. They transplanted into a 35-year-old man suffering from Addison's disease, the freshly obtained adrenal of a young pig. The organ was freed from both poles and about two-thirds of the freshened flap was implanted into the scrotum (local anæsthesia) after opening of the tunica albuginea and removal of a like piece of scrotal tissue, the tunica then being resutured. The operation was borne without disturbance, the subjective symptoms improved, the appetite increased, the vessel tone was better and the skin pigmentation was lessened. About two weeks after the operation asthenia set in, the blood-pressure fell, and a day later coma, followed by death. Microscopically, the transplant was found to be adherent to the scrotal tissue, and was separated from the adrenal tissue only by new formed fibres arising from the latter. The cortical substance was rich in blood-vessels and stained well, the medulla in greater part was necrotic and only a few cells could be made out.

Hypophysis.—Transplantation of the hypophysis was first performed by Cushing. He was able to prove that the life of an animal in whom the hypophysis was totally removed could be prolonged after

autotransplantation. Crowe, Cushing and Homans report that in 23 transplantation experiments on hypophysectomized dogs, in only 7 cases was the extirpation fatal, while in the remaining 16 cases smaller or larger fragments of the anterior lobe were removed. The transplants were placed in the abdominal muscles, in the bone marrow and occasionally with good results in the subcortical portion of the brain. Out of three cases of the last type, one animal died after 48 hours and the transplanted tissue was found to be completely necrotic. A second adult dog showed no disturbance except glycosuria and was killed on the 18th day. In the transplant there was found a normal peripheral zone, containing well stained anterior lobe cells, the central portion was necrotic and in the surrounding brain tissue were many colloid bodies. In the third case there were mild symptoms of cachexia, and on the second day the animal was in normal condition. This animal was killed on the fifteenth day and the findings were like those in the second case. Crowe, Cushing and Homans conclude from their investigations that transplantation of the hypophysis, after complete hypophysectomy, prolongs the life of the experimental animal. Homotransplantation, one or two days after hypophysectomy, yields better results than transplantation before removal of the hypophysis. Attempts to prove functionating of the transplant by subsequent removal yielded negative results in two cases.

Transplantation after partial hypophysectomy prevented in many cases the development of cachexia. In a young dog, after partial and coincident transplantation of the hypophysis into the rectus muscle, mild symptoms developed, which soon disappeared, and a month later they reappeared in increased severity and after homotransplantation, promptly disappeared. Transplantation investigations were undertaken by Bayer, Biedel, Clairmont and Ehrlich for the purpose of establishing hyperpituitarism without result. Transplanted hypophysis can heal in the spleen and intact cells can be found 10 to 14 days later, which finally become necrotic. Shaeffer's work on dogs, cats, apes and rats, transplanting the hypophysis into the brain substance, the subcutaneous tissue, muscle, peritoneal cavity and kidney, was not crowned with any permanent success. There only appeared a temporary increase in urinary secretion. Changes in development and nutrition were not observed. Very interesting was the investigation of A. Exner, who transplanted 7 to 10 hypophyses of like animals into the retroperitoneal space of young rats, using the weaker mates as controls. In 9 out of 11 cases the experimental animal gained in weight over the controlled animals in from 13 to 30 days. The increase in weight was due partly

through an increase in fat and partly through increase in size of bones. On section it was shown that the transplanted hypophyses were absorbed; in only a few cases could the transplanted hypophysis be demonstrated as necrotic cell masses. Whether or not the increase in weight was due to functionating of the transplanted hypophysis or the absorption of its active substance from the disintegrating tissues, was not decided.

Ovaries.—In 1895, Knauer reported regarding autoplastic transplantation of the ovaries. This was performed on rabbits, the ovary being removed from its normal site and transplanted into the mesometrium of the cornu of the uterus, or between the abdominal fascia and musculature. Where successful healing took place, there was no atrophy of the uterus as is usually noted following castration. These observations were confirmed by a number of investigators. The transplanted ovary retained its normal morphological structure, showing well preserved epithelial cells and follicles with unchanged or only a partially degenerated ovarian and well staining interstitial tissue. No difference was noted whether the transplant was pedunculated or not. The permanency of function and preservation of structure of the transplanted ovaries is not lasting, since after a number of months regressive metamorphosis is noted. Kawasoye found after extirpation of both tubes and ovaries with transplantation of half of one ovary into the broad ligament, that 90 days later there was atrophy and destruction of the follicles, degeneration of the ovum and necrosis of the stroma, while after removal of one ovary and transplantation of half into the remaining tube the degeneration was not so intense. Fogus found, after planting ovary into the spleen, that nine months later there was pigmented cicatricial tissue at the site of transplantation.

In homoplastic transplantation, Knauer and Carmichael were not always successful. The transplant rapidly degenerated completely in the researches of Marchese, Herlitzka, and others, while Vish, Foa, McCone, Basso, Lukaschewitsch, Magnus and Guthrie report successful homotransplantation, with not only preservation of the morphological transplanted ovary, but also later regular and normal ovulation, conception and pregnancy. The possibility of conception was proved conclusively by the researches of Guthrie, who exchanged the tubes of pure white and black hens. When the ovary of a white hen was planted into a black one, and this hen was impregnated by a white male, the offspring were white, black and spotted. The conclusions which Guthrie drew from this experiment have been disputed by Davenport and others, but the fact that the offspring were of the color

of the donor of the tube, is positive proof that the birth of these eggs was from the implanted foreign tube. Foa worked out transplantation of embryonal ovaries and was able to prove that they reproduced in a normal manner. In autoplastic transplantation, it makes no difference where the ovary is transplanted. Halban found in transplantation under the skin, good development of the uterus and genitals, and the transplant did not degenerate. Marschall and Joli, who transplanted ovaries intraperitoneally or into the kidneys, found no sign of degeneration of the uterus, the transplant in the castrated animals healing well, it apparently making no difference whether the epithelium was preserved, or, as happened in most cases, it became absorbed, the follicles disappearing and the implanted organ only remaining as an interstitial remnant.

In most cases of heteroplastic transplantation, there was no success, although there are some successful reports. Bucura obtained the best results. He transplanted the tubes of guinea pigs into castrated rabbits and found that not only did they heal, but they were capable of function, in that the follicles matured and prevented post-castration atrophy of uterus. Schultz obtained good results in transplantation of the tubes in different varieties of the same species, as with transplantation of the tubes from common guinea pigs into rosette guinea pigs and *vice versa,* between silver rabbits and land rabbits and *vice versa.* The results were apparently permanent, since the epithelium, the follicles and the ova retained their normal structure six months later. Ovary transplantation to foreign species, from the cat to the mouse, from the Japanese dancing mouse to the white mouse, from the dog to the rabbit, from the guinea pig to the rabbit, from the cat to the rabbit, from the mouse to the cat, from the rabbit to the dog, from the white mouse to the Japanese dancing mouse, healed well, and after 14 days was still well preserved but then began to show signs of disintegration.

Transplantation of the ovaries in the human female probably was carried out for the first time by Morris in 1895, in a woman of twenty, with an infantile uterus and amenorrhœa, good healing took place and menstruation followed two days after ovary transplantation. Transplantation and reimplantation of ovaries in women, especially after oöphorectomy, has been many times performed for the prevention of post-operative disturbances. The castration atrophy was prevented and almost regular menstruation occurred. Halliday, Croom, and Morris saw, after ovary transplantation, pregnancy and birth of a normal child.

In a 32-year-old woman, in whom 5 years previously one tube was

extirpated, while removing the second ovary for a tubo-ovarian cyst, Kayser planted two portions of microscopically unchanged portions of this ovary into the right thigh through an incision so that it lay beneath the vastus externus muscle, fixing it with catgut sutures and covered it with the fascia lata. Menstruation occurred regularly. It appeared after 23 days, was painless and there were no untoward symptoms. Kayser therefore concludes that it is only necessary to implant small portions of ovary in order to prevent symptoms due to ovarian insufficiency.

Testicles.—Testicular transplantation has been carried out for a long time. As early as in 1849 Berchtold successfully transplanted testicles of roosters with good functional results. Regarding the preservation of transplanted testicles, Mantegazza and Bizzozzero, Herlitzka and Zalchas, with frogs, Lode with roosters and Ribberta with nursing animals, showed that the transplanted testicles for a time generate spermatozoa but later undergo a regressive metamorphosis and after a time completely degenerate. Fogus in his researches found after transplanting testicles into the spleen that they became completely absorbed. Foa obtained like results in performing autoplastic and homoplastic transplantations in dogs as well as in new-born animals, even though he used small pieces of testicles as well as entire testicles. Maxikoff and later Cevoloto, after histological studies, came to the conclusion that the epithelial tissue of the seminal canals is very delicate and after implantation, the sperm-generating tissue disintegrates, and that the highly differential cells are replaced by a more simple type of epithelium, so that the canals become obstructed and are lined only by the cells of Sertoli. Anyway Fogus was able to implant small portions of testicles with result that they still contained living spermatozoa after months. Roosters which have been completely castrated and transplanted with functionating testicular tissues, it is true, do not develop all the characteristics of the male, yet they are not typical capon. Whether the absence of these characteristics, as Fogus believes, is due to the scarcity of the transplanted portion of testicle, or to the absence of union between the testicle and the vas deferens, as Nussbaum states, is not yet decided.

Steinach attempted to attain complete development of the epididymis, the prostate and penis in young mammals by means of autoplastic transplantation of both testicles. The sexual desire and potency of the animals were awakened at the proper time and appeared in normal intensity. The development of the male characteristics, the general carriage which this immature animal showed, imitating the adult, was

due to the influence of the testicles. Morphological examination showed that the semen generating portions did not develop but the tissues which manufacture the inner secretion, had developed very markedly.

Castle and Philipps in 33 attempts did not succeed in homoplastic transplantation, as the transplanted testicles always became necrotic. Pogany united two young rats by parabiosis and transplanted their testicles together with the epididymis. The second testicles of both animals were extirpated. After 10 to 14 days, the animals were separated, the pedicles of the organs being divided. Thus each animal had a testicle from the other. As long as the testicle had its pedicle, it retained its structure, but after division of the pedicle, the testicle rapidly broke down and became absorbed. Heterosexual transplantation of the genital glands has been attempted many times. The sex of the recipient has no influence upon the structural preservation of the transplanted gland. In the researches of Herlitzka and Bersca on watermoles, after a few months the testicles remained as fibrous rudiments. Ovaries implanted into males rapidly disintegrated. W. Schultz, after implanting ovaries into male guinea pigs, found that they develop and, even after four months, contained well preserved epithelium and follicles; and Busura found in castrated female rabbits in which testicles had been implanted, after 58 days, well preserved seminal canals, containing spermatozoa. In order to determine the effect of the inner secretions of the heterosexually transplanted genital glands, Fogus obtained positive results in young hens, in that one year after testicular transplantation, they developed the characteristic head and beard growth of the male, while they retained the spurs and feathers of the female. In one case after autopsy, no sign of the transplanted testicle could be found, while in the second case, there was demonstrated at the site of transplantation, a fibrous tumor, rich in blood-vessels. Both hens laid eggs and Fogus himself believes that there was no proof of any influence of a heterosexual gland upon the secondary sexual characteristics.

Steinach castrated young male guinea pigs and rats and implanted them at the same time with ovaries from the females of the same animals. He found that the ovaries transplanted peritoneally or on the inner surface of the abdominal muscles, subcutaneously, healed, developed and functionated in the male organism. The follicles developed into larger follicles with normal ova and in part arrived at full maturity, burst and became in part corpora lutea. The interstitial cells of the stroma also showed a tendency to reproduction. The transplanted ovary

was undersized and did not attain the size of the fully developed ovary in the normal female.

The implanted ovary had apparently no influence upon the development of the male. The male characteristics, which reach their complete development before or with puberty, as the erectile tissue of the penis, the prostate, and the seminal ducts, remained in their infantile states, as after ordinary castration, and the inhibitory effect of the ovary could be noted upon the development of the penis and the erectile tissue in male rats. The transplanted ovary exerted a stimulating influence upon the tube and uterus which had been transplanted with it.

Particularly noteworthy was the change of the minor sexual characteristic of the male to typical female organs. In those male guinea pigs which had been castrated and into whom had been transplanted ovaries, there was a remarkable development of the breasts and nipples, their shape and size resembling those of normal females. In normal females, the mammæ begin to develop vigorously at about the third month. The pigmented area about the nipple becomes broad and elevated, remaining free from hair, the pregravid completion of the development progressing gradually. In the operated males this process is accelerated and the male rudiments rapidly are transformed into female organs. The glands attain the size of those of adult females about 8 to 10 months old, and in fact, may even outgrow these. The microscopic examination shows that these breasts which have enlarged because of transplantation, are very similar to the ripe adult female breasts.

The influence of the transplanted ovaries extends over the development, the size and the form of the body and skeleton of rats and guinea pigs. The tendency to rapid, vigorous male growth, after transplantation, is lost in a short time and a transformation toward the gradual weak female development appears. The animals with the transplanted ovaries after a time take on the size and form of females. Growth of hair and fatty deposits bring out the female characteristics, and even psychic changes can be recognized.

Kidney.—The first successful kidney transplantation was demonstrated in 1902, although before this time Lubarsch and Alessenry were able to transplant small pieces of kidney tissue into the spleen and lymph-nodes, in order to demonstrate what changes occur in the kidney tubules. I first automatically transplanted the kidney in a neighboring site in a pig with failure because of the difficulties due to the anatomy of the veins in this animal. The first transplantation on the dog failed, because the dogs scratched themselves in the location of the transplanted

kidneys or because of infection due to licking of the wounds. Only when the kidneys were transplanted into the necks of the dogs were the investigations fruitful. Following the suggestion of Payr, I was able to unite the renal artery with the carotid and the renal vein with the jugular vein. I sutured the ureter into the skin wound. Urinary flow from the ureter was at once established, although in the first dog, the ureter after 5 days became swollen and retracted to such an extent that it became invisible and the urine flowed directly from the wound. Further researches taught me that the kidney itself could be made to preserve its function up to 18 days. Autopsy *in vivo* demonstrated distinct changes in the transplanted kidney which was so densely adherent to the surrounding tissues, that when the capsule was freed, hemorrhage occurred from numerous newly formed blood-vessels.

A. Exner attempted similar transplantation without satisfactory results, as in the old Vienna Physiological Institute strict asepsis could not be observed; in spite of this he was able to note urinary flow from a ureter two days later. Stich, Makkas and Bowman transplanted the kidneys into the necks of a series of dogs. Ten days later the animals died of pyelonephritis. For this reason they implanted, in a second series, the vessels of the kidney into the iliac, and the ureter into the bladder. The other kidney was not removed. On the first day after operation, the urine was somewhat bloody but later became clear. Three weeks later the animal died of infection. Autopsy disclosed numerous abscesses in the region about the transplanted kidney, the latter being macroscopically normal and microscopically showing a well preserved epithelium with no evidence of parenchymatous or interstitial nephritis. Very important were the researches which Zaaijer carried out in 1908. He transplanted the left kidney of a dog into the groin, uniting the vessels with the external iliac artery and vein, and sutured the ureter into the bladder. Eighty-three days later he removed the right kidney. The transplanted kidney functionated, proving the functional value of kidneys transplanted by autoplasty.

Later Carrel extirpated both kidneys in dogs and replanted one into the kidney region. Out of 6 dogs, 5 survived the procedure, one was killed 21 days after operation, 2 developed secondary contraction of the ureteral anastomosis, dying respectively 17 and 31 days after operation, the fourth animal died two months later because of pyelitis. One dog developed minor complications and 8½ months later was in the best of health. That the implanted kidneys carried out their functions was proven by the good condition of the animals until complications developed. Borst and Enderlen performed transplantations of six kid-

neys, joining the renal vessels to those of the spleen, three of the animals being observed for 34, 56 and 118 days. The kidneys were found in faultless condition, macroscopically and microscopically, functionated well, and one animal, in which the second kidney was removed 18 days later, lived in good condition another 100 days.

The first homoplastic kidney transplantation was performed by myself. I was able to prove three months after my first demonstration that I was successful in transplanting the kidney of one dog into the neck of another, the transplanted kidney after a few days secreting normal urine and completely healing in its new location.

In order to test the functional value of homoplastic transplantation of the kidneys, Carrel and Guthrie at first, later Carrel alone, undertook experiments with various methods. They removed the blood-vessels with the immediate portion of the aorta and vena cava and sutured the flaps into respective openings into the analogous vessels of the recipient. Following this method, the operated animals lived for a longer period of time, there occurred in every instance changes in the site and length of blood-vessels which finally led to chronic stasis, and after a number of weeks, to severe disease of the kidneys. Yet, in one cat, three months after operation the transplanted kidney was demonstrated with normal coloring and shape, and the animal enjoyed good health. Finally, the kidney became smaller, and Guthrie one year later found that it was shrunken and incapable of function. Further attempts were designated as transplantation *en masse* by Carrel and Guthrie. This consists of removing from one animal both kidneys with their blood-vessels, the corresponding segments of aorta and vena cava, together with the nerves and ganglia, the ureters, and a part of the bladder, and implanting them into the abdominal cavity of a second animal, in whom both kidneys had been previously removed. An oblique incision had been made into the aorta and vena cava, and the vessel segments of the first animal were sutured into the ends of the aorta and vena cava, and the bladder segments into the bladder of the experimental animal. The successes of Carrel were extraordinary. Twenty days after this operation the cat was in remarkably good health, its urine was normal. She suddenly died 31 days after operation. Microscopical examination demonstrated an acute interstitial nephritis as the cause of death. A second cat, which remained well for 18 days, died 36 days later of a severe arteriosclerosis which Carrel believes was due to the influence of the new kidney. The first heteroplastic transplantation of the kidney was performed by myself, transplanting the kidney of a dog into the neck of a goat. I demonstrated this goat to the Society for

Physicians in 1903, and the 100 present were able to see a distinct flow of urine from the sutured ureter, thus disproving the statement of Villard that this flow was due to œdema. There was no evidence of œdema. On the next day, when I examined the flow of urine, it had ceased because of thrombosis of the blood-vessels. Carrel transplanted the kidney of a rabbit into a cat. After a period of weeks, the rabbit's kidney was completely absorbed. He also transplanted the kidney of a pig into a dog. Fifteen days later the animal died of infection of the kidney, the size of the latter being about normal.

As early as 1902 I transplanted the kidney of a pig into a woman suffering with uræmia in the severe form. The transplantation was attempted in the left elbow region, but I could not surmount the technical difficulties and, also, the animal died from the anæsthetic. Five years later, Jaboulay attempted heteroplastic transplantation in two incurable nephritics, utilizing the elbow-joint as the site for a goat kidney in one case, and a pig's kidney in a second case; anastomosing the brachial artery and the cephalic vein with the renal artery and renal vein respectively; three days later the kidneys became gangrenous and had to be removed. Into a 21 year old girl, suffering with severe hemorrhagic nephritis, Unger attempted to transplant a kidney of a ten year old ape (Macacus Nenestrinus); 32 days after the operation the patient died of œdema of the lungs. Circulation was maintained in the ape's kidney, it apparently was alive 32 hours after the operation, but the question could not be decided whether it functionated or not, since it was not clearly established whether the fluid in the ureters was urine or œdematous fluid. Portions of the kidneys were unchanged, while other portions showed acute inflammatory changes in the renal tubules.

Spleen.—Lüttke transplanted by homoplasty the spleen of rabbits into the peritoneal cavity, and by heteroplasty into the dog, as well as into a pocket of the spleen itself. The transplanted splenic tissue was demonstrated only for four weeks; after two or three months it completely disappeared. The question as to whether or not the transplanted spleen functionated, was studied by examination of the blood. In the first two weeks the hæmoglobin and the erythrocyte contents diminished, while the lymphocytes increased fourfold. The eosinophilic cells after two or three weeks increased in number. Lüttke interprets the increase in lymphocytes as indicative of the functionating power of the transplanted spleen. The functional ability is also proved by the recognition of specific antibodies. In six out of ten cases in which Lüttke transplanted the spleens of rabbits which had been immunized

against typhoid fever, by heteroplasty, into dogs and apes, he was able to demonstrate the presence of typhoid agglutinins. Passive immunity was not conferred simply by transfer, but was the result of an active production of agglutinins by the transplanted splenic tissue. This was proved by the fact that the serum of dogs and apes which had been immunized against typhoid fever by the transplanted rabbit's spleen, contained a great agglutinin content, and retained it for three months; while control animals which had been immunized by the injection of splenic extract from immunized animals, contained less agglutinins, which disappeared in from three to six weeks. Carrel reimplanted a spleen which had been washed in Locke's solution, followed by healing without reaction. Since this operation is relatively simple, Stich believes that the possibility of homoplastic transplantation of the spleen is more likely to be successful than that of thyroid and kidney.

Pancreas.—Autoplastic pancreas transplantation was attempted by Coffey on dogs. Minkowsky successfully transplanted a portion of the pancreas with a vascular pedicle, the latter being later divided. The transplanted segment healed, and it was shown that it was able to prevent the onset of diabetes. Since then Heron was able to transplant pancreatic tissue into the spleen of pancreatized dogs, in the attempt to improve diabetic symptoms and to prolong the lives of the animals.

Intestine.—The idea of enteroplasty occurred to Nicoladoni, who made the suggestion that the construction of an artificial anus after complete resection of the descending colon could be obviated if the removed portion of large intestine could be substituted by a portion of neighboring small intestine which had been lengthened by means of an incision into the mesentery. The borrowed intestine was inserted into the defect of the large intestine and the mobile ends of the small intestine were sutured together. This method was useful in resection of the stomach between the pylorus and cardia, provided that the mesocolon could bear a double incision in order to free the enclosed transverse colon from the gastrocolic omentum. A second method of operation carried out by Nicoladoni was the following: The neighboring small intestine with its mesentery was incised obliquely. The divided ends of the large intestine were united with this incision in such a fashion that the continuity of the intestine was established so that the contents progressed through a portion of the intestinal tract by means of retrograde peristalsis. The success of this second method naturally depends upon the possibility to permanently reverse the peristalsis of a large portion of the intestine, as the contents must, after they pass the first suture line, proceed through the large intestine against the valve of Bauhin, until they find their way

through the reversed, inserted portion of the small intestine, finally being emptied into the rectal extremity of the gut. Digestion must also be reversed. Intestinal digestion must also take place in the transverse colon and fecal bodies must pass through the small intestine shortly before their exit from the body. The principles upon which both operations were founded are very original. The first type of operation will make it possible to insert a substitute for the stomach in resection of that organ, in that the transverse colon, after it has been divided from the descending colon, is implanted in the place of a stomach with its divided mesocolon; the portion of pylorus lying to the left of the operator being sutured into the end of the colon, also lying to the left of the operator, the cardia being sutured on the right side into the other colonic extremity. The success of the operation depends upon the fact that the implanted colon is nourished from the blood-vessels of the divided mesocolon; and, second, that there occurs no disturbance after union of the colon with the stomach, which would be due to a difference in the reaction of the stomach—stomach contents being acid, colonic, alkaline.

I have succeeded in transplanting portions of the intestinal tract in pigs, planting large intestine into the stomach, the stomach into the large intestine, small intestine into the stomach, the stomach into the small intestine, small intestine into large intestine and large intestine into small intestine; the experiments were done on young animals, nursed by their mothers. Three out of eighteen of the animals died, the survivors bore the operations well, they showed no disturbance in digestion, being fed on milk one day after operation, after six days on farinaceous food, and after ten days resumed their normal diet.

Transplantation of the Large Intestine to the Stomach.—The cæcum has been transplanted into the stomach in the following fashion: The blind end of the cæcum was removed and by means of a transverse incision was transplanted into the anterior wall of the stomach so that it formed a little pouch. Silk was used here as well as in the following cases. The sutures were in double rows, the deep layer being seromuscular and the superficial ones serous. The animal survived the operation well and 100 days later was killed. On opening the abdomen, there were present a few adhesions of the stomach to the omentum. The sutured head of the cæcum was completely adherent to the stomach, the peritoneum was even and smooth. The lumen of the caput was not contracted. The differentiation between the inner surface of the stomach from the wall of the cæcum was macroscopically visible, the difference being noticeable, not only in the color, but also in the arrange-

ment of the mucous membrane, that of the stomach being thicker and more massive than that of the implanted segment.

The gastric mucous membrane in the immediate neighborhood of the implanted portion was more wrinkled than that further away, which was smoother. The junction between the stomach and the cæcum in some places only was marked by a light, superficial swelling.

Three portions of this tissue were utilized for microscopic examination, first, the swelling; second, the portion of the cæcum; third, the border without swelling. The swelling was confined to the large intestine. The enlargement was due to hypertrophy of the lymph follicles of the implanted intestines, no other changes in the mucosa being observed. The muscularis in the middle of the implanted portion, as well as in a swollen and normal portion, is thickened, this being probably due to ring formation. The stroma is no more vascular than that of the normal intestine, while the submucosa is distinctly richer in vessels than the normal, as well as thicker and richer in connective tissue. Of interest is the fact that the number of ganglion cells in the submucosa is unchanged; the intestinal plexus is apparently intact. It was noted regarding the finer structures of mucosa that the superficial epithelium which covers the spaces between the gland mouths is unchanged, and that they are covered by columnar cells as in the normal gut. The beaker cells in the depths of the glands are not as numerous. It is noteworthy that the implanted large intestine gave a distinct acid reaction, showing that it came in contact on all sides with the gastric juice.

Transplantation from the Stomach Into the Small Intestine.—A portion of the wall of the small intestine opposite the mesenteric attachment was removed from that part of the intestine which could be brought in contact with the stomach without difficulty. The extirpated piece was six centimetres in length and 3½ in width. Into this defect was planted a portion of the gastric wall. The stomach wound was then sutured. The animal, which remained under the influence of the anæsthetic for a long time, bore the operative procedure well, soon began to eat regularly and with a good appetite, digesting its food well. Seventy-seven days after operation it was killed. On macroscopical examination, a distinct difference between the two varieties of mucous membrane could be recognized. The mucous membrane of the stomach was continuous with that of the intestine, it is true, but that of the intestine was thicker and protruded more prominently into the lumen of the gut and its color was a deeper red. It must be admitted that the implanted segment became smaller in size. Examination with a magnifying glass as well as under higher power reveals a reflection of the

gastric mucosa over that of the intestine. The mucous membrane of the stomach is lined by one layer of columnar epithelium as usual.

Transplantation from the Stomach Into the Large Intestine.—Implantation of a rectangular piece of stomach into the transverse colon. The animal after the operation was in good shape and gained in weight. On examination 53 days after operation, the transplanted stomach is readily found, and the different varieties of mucous membrane are easily made out. The gastric mucous membrane protrudes somewhat into the lumen of the gut, it is thicker and redder and there are present on its surface definite elevations and depressions. Even with the naked eye one can perceive a swelling at the junction of the mucous membranes, which with the magnifying glass is found to be present in the intestinal wall. This swelling affects only the mucous layer and in the submucosa is present a cellular infiltration, although there is no evidence of abscess formation or disintegration. At the site of the swelling there is a wealth of vascular tissue.

Transplantation from the Small Intestine Into the Stomach.—From the anterior wall of the stomach a portion five by three centimetres is excised. A low lying loop of the small intestine is selected and a portion about six centimetres in length is removed, and by means of a generous incision, the mesentery is mobilized. The open lumina of the loop are then resutured and on the wall opposite to the mesenteric attachment a long incision is made. The small intestine is then fitted over the wound in the stomach like a cap. At the same time the continuity of the gut was re-established by means of sutures. The pig was killed 99 days after the operation. At autopsy was found a swelling on the anterior wall of the stomach which was found to be the transplanted intestine. On opening the stomach one finds in this intestinal pocket the same food contents as in the rest of the stomach.

Transplantation of an Unpedunculated Gastric Flap Into the Small Intestine.—A rectangular portion of the anterior gastric wall 4½ by 3 cm. was excised and sutured in the place of a small piece of small intestine which had been removed. The animal was killed 13 days after. On section the stomach was found to be healed. No adhesions. The gastric mucous membrane was easily differentiated from that of the intestine. Microscopically the section appeared normal.

Insertion of Small Intestine Into the Colon.—The grafting is performed in such a manner that the direction of the peristaltic waves was not changed. A portion of small intestine 8½ cm. long was implanted into the colon, by my method of intestinal anastomosis. One hundred and ten days after the operation, the animal was killed, it weighed twice

as much as at the time of operation. On section, a difference between the small and large intestine was distinctly visible. Externally there was seen a contraction corresponding to the line of union, although there was no difference in color. The mesenteries were united, somewhat thickened, and folded over one another. The mucous membrane everywhere was normal, at the most, there was a slight thickening at the site of junction.

The conclusions that I derived as to transplantation of the intestine was, that it is easily performed on the pig and that these animals survive the operation for a long time and gain in weight after it. I have been asked by Dr. Exner in what manner the foreign piece of mucous membrane protects itself against digestion by the intestinal juices. Many theories have been advanced to answer this question. From the result of my researches it appears that each portion is able to protect itself against the foreign digestive juices, and that when the two varieties of membrane unite, the one of least resistance undergoes swelling.

Rosenberg resected a loop of intestine in the dogs, opened the gut longitudinally and planted it into the incised urinary bladder or into the bladder, the upper half of which had been removed. The transplanted intestine healed and after 2, 4, and 15 weeks did not contract. The intestinal epithelium disappeared and was replaced by bladder epithelium. Transplantation of the intestine as a substitute for the œsophagus has been performed in a number of cases and the intestine healed in its entire length in the subcutaneous tissue between the sternum and the skin.

Prostate.—Scrralach and Parre attempted prostatic transplantation by implanting small or large pieces of the prostate subcutaneously or intraperitoneally. The transplanted tissue changed, in that the glands atrophied and the connective tissue hypertrophied.

The hopes which were entertained 15 years ago regarding tissue and autotransplantation have been partially fulfilled; in heteroplastic transplantation it appears that the obstacle to success lies in anaphylaxis, while in homoplasty inherent biochemical characteristics interfere with healing. On this ground only can be explained the unsuccessful results of these types of transplantation as compared to the more favorable and more permanent results in autotransplantation. In heterotransplantation relatively successful results have been obtained, as it is finally replaced by the bone of the recipient. The cell protoplasm, specific for each organism, varies with the individual.

There are as many protoplasms as there are individuals. Thus in homotransplantation the appearance in the body of a foreign protoplasm calls forth ferments into the circulation which destroy the transplanted tissue. The statement of Roux which he made in 1895 that a part of an organism will accustom itself to the surroundings in another organism cannot in this era be accepted. Whether it is possible or not to artificially alter the bloods of two individuals so that homotransplantation will be successful, is questionable. For this purpose, one could resort to parabiosis.

CHRONIC ULCERS OF THE STOMACH AND DUODENUM*

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First Period: 1893 to 1900. Pyloric Obstruction.—The first case of pyloric obstruction in St. Mary's Hospital was operated on in 1893. This operation was a Heinicke-Mikulicz pyloroplasty. The second operation was a gastrojejunostomy with the Murphy button. From this time on, a gradually increasing number of such operations were performed in our clinic. However, only those cases with marked obstruction at the pyloric end of the stomach were operated on and at the time of the operation the obstruction was believed to be the result of gastric ulcer, although the exact location of the ulcer, whether in the pyloric end of the stomach or in the duodenum, was not determined.

Second Period: 1900 to 1906. Growth of Knowledge the Result of Surgical Observation.—During this period it was recognized that obstruction was a terminal condition and a study of the subject was commenced with a view to the earlier termination of a malady, which exposed the patient to serious dangers and more or less constant disability and distress. There was much discussion of mucous ulcers, erosions, and a variety of supposed lesions which was not the result of actual observations at the operating table, but of an attempt to furnish a pathologic basis for the symptoms complained of by the patient. This atmosphere of uncertainty gradually disappeared and patients were explored for symptomatic indications, but not operated on unless a pathologic basis for those symptoms could be demonstrated at the time of the operation. The Murphy button was gradually abandoned for the suture and the anterior method of gastrojejunostomy replaced to as great an extent as possible by the posterior.

Third Period: 1906 to 1914. Development and Improvement in Diagnosis.—The great value of the history and physical findings in diagnosis was emphasized. The relation of the clinical symptoms to the lesion was shown in the light of operative experience and the value of the purely laboratory examinations of gastric contents were found to have been over-estimated. The Röntgen ray gradually won

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first place in the diagnosis of these lesions and the necessity for the excision of gastric ulcers, because of the menace of cancer, was recognized.

Our Present Status.—Up to December 31, 1913, 1841 cases of acute and chronic ulcers of the stomach and duodenum had been operated on in St. Mary's Hospital. Of this number, 437 were females and 1384 were males. The early clinical view of a preponderance of females over males was thus shown to be in error. It is probable that a large number of these supposed ulcers in women were in reality the result of pyloric spasm due to cholelithiasis or some intestinal lesion which gave rise to the gastric disturbance.

In 636 of the 1841 cases, the ulcers were located in the stomach and, in 1205 they were located in the duodenum. It must be borne in mind that all of the early cases were supposed to be gastric and so classified. The percentage in the last 1000 accurately observed cases showed 73.8 per cent. duodenal and 25.2 per cent. gastric. Of the gastric, 29 per cent. were females and 71 per cent. males. Of the duodenal, 21 per cent. were females and 79 per cent. males.

In differentiating between an ulcer in the pyloric end of the stomach and one in the first portion of the duodenum, the situation of the pyloric veins is the determining factor. Just at the pylorus, from above and below, short, thick veins, usually 1 to 2 cm. in length, come into view from behind and pass forward. There is a distinct notch at the points of emergence of the veins. From these veins there usually extends an arching vein from each side, sometimes uniting, forming the pyloric vein, sometimes ending in a spray. This superficial pyloric vein is not so characteristic as the thick veins I have just described, but, when present, it is a ready means of differentiation.

The terminal three-fourths inch of the pyloric end of the stomach is not often involved in ulcer. The more common seat of gastric ulcer is along the lesser curvature, often saddle-shaped. The ulcer is more often on the posterior than the anterior wall. But whether situated anteriorly or posteriorly, a superficial ulcer at the point of contact often appears on the opposite wall, the "contact" ulcer. The gastric ulcer itself is, as a rule, clean cut, with a hard grayish-white base, and is round or oval in shape. Outside of its crater there often is a massive infiltration into the outer layers of the muscularis and peritoneum. Over this, very frequently, protective adhesions are found sometimes binding the seat of the ulcer to other organs, such as the pancreas or liver, a condition of incomplete or protected perforation. The indura-

tion is always very much more extensive than the actual crater and is not entirely dependent on the size of the ulcer. The situation of the ulcer, however, may be at any point in the wall of the stomach.

Multiple ulcers are not frequently found at operation, which is contrary to the early views based on clinical observations and post-mortem findings in deaths due to acute ulcerative processes in the stomach. These processes were usually gastrotoxic in origin and not often the source of chronic ulcer. Multiple ulcers of the stomach and duodenum or separate ulcers of the stomach and duodenum exist in the same case in about 5 per cent. of the cases.

The character of ulcers of the duodenum differs in many respects from that of ulcers of the stomach. They are usually to be found in the upper two inches of the duodenum and more often in the anterior-superior wall. When found on the posterior wall, they are usually of the same character as when found in the stomach. A typical crater and the contact ulcer on the anterior wall may give rise to an independent induration. As a rule, the duodenal ulcer has its origin below the pylorus, but when it extends toward the stomach it usually stops short at the pylorus, which it may undermine. In exploring for ulcers of this description I have occasionally had difficulty in discovering the posterior ulcer because it was concealed underneath the projecting pyloric ring. The mucous membrane of the upper duodenum is thin and granular and ulcers confined to the anterior wall, if they take upon themselves the crater-like character of the gastric ulcer, will develop a localized mass over the site of the ulcer. Many times, however, no crater is found in the mucous membrane in duodenal ulcer, but rather a discolored, moth-eaten patch in the centre of which may be a dimple-like ulcer and outside of this a typical induration. It is probable that this variation from the ordinary type of gastric ulcer explains why duodenal ulcers have been so frequently overlooked at autopsy.

There is a variety of duodenal ulcer which sometimes occurs in the region of the papilla of the common duct, giving rise to attacks resembling gall-stone colic and profuse hemorrhages. The three cases I have had an opportunity to examine have all been seen post mortem; the patients dying from acute hemorrhage after prolonged symptoms resembling cholelithiasis.

Incomplete protected perforation of duodenal ulcer, giving rise to localized peritonitis covered by adhesions, is common. The observation of such patients operated on during an attack has shown a localized peritonitis in the vicinity of the ulcer which makes it probable that an

actual leakage had taken place but that the resistance of the peritoneal cavity was sufficient to care for the comparatively small amount of more or less sterile secretion which escaped. Occasionally this localized infection results in a phlegmon, sub-diaphragmatic or otherwise.

Indications for Operation.—In the early history of the disease long periods of remission may occur in which it would appear from the symptomless course that the ulcer had healed. Yet case after case operated on during the period of remission does not show the ulcer to be healed—thereby repeating the history of appendicitis and gall-stone disease inasmuch as the recovery from each attack is erroneously supposed to be a cure. Permanent healing of chronic ulcers of the stomach and duodenum by non-operative means must be of rather infrequent occurrence. That a large number of acute, subacute, and some chronic ulcers are cured permanently cannot be doubted, but if they fail to show permanency after a reasonable attempt at cure under ordinary conditions of life, the patients should be treated surgically, not only from the standpoint of the disability of the patient, but also from the standpoint of mortality. The patient with ulcer treated medically is in far greater danger of death from hemorrhage, perforation, obstruction or cancerous degeneration than he is from an operation. Those patients who can afford to carry on prolonged treatment are, of course, in better condition for non-operative therapy than is the working man who must earn his living and live on those things which he can obtain.

THE SURGICAL TREATMENT

Gastric Ulcer.—Gastrojejunostomy is the most generally useful operation for gastric ulcer and has a wide field of application. Especially is this true when there is obstruction in the vicinity of the pylorus. It may be said that the greater the obstruction within limits, the more immediate and permanent the results of gastrojejunostomy. It is probable that gastrojejunostomy is of value not only as an operation for drainage, but that it also changes the physiology of the stomach and brings a greater measure of relief than can be achieved without it. While posterior gastrojejunostomy is the operation of choice, in certain cases adhesions may prevent its use. In these cases the anterior operation has given good results. For those ulcers which lie in the body of the stomach and in which the gastrojejunostomy must be made beyond the point of ulceration the results are less favorable.

Because of the menace of cancer all ulcers of the stomach, without regard to their situation, should be excised if possible. In our expe-

rience local excision of the ulcer without gastrojejunostomy has sometimes failed to affect a cure. I believe, therefore, that, as a rule, gastrojejunostomy should be done in addition to excision.

When a resection in continuity of the stomach with end-to-end union has been made for chronic ulcer, the results have been excellent without gastrojejunostomy.

For posterior ulcers of the body of the stomach which have become adherent, especially to the pancreas, transgastric excision of the ulcer has been of service.

In *hour-glass* stomachs gastrogastrostomy is a desirable operation, although resection in continuity when it can be done has given good results. In some cases, gastrojejunostomy fulfills the indications admirably.

When the ulcer occupies the pyloric end of the stomach, the pylorectomy of Rodman gives excellent results, both immediate and remote.

In those ulcers of the body of the stomach that cannot be excised and in which gastrojejunostomy cannot be done, temporary jejunostomy is distinctly useful, especially in cases in which a differential diagnosis between malignant and simple ulcer cannot be established. The procedure gives prolonged rest to the stomach and maintains good nutrition. Jejunal feeding may be maintained for several months with distinct advantage.

Ulcer of the Duodenum.—Gastrojejunostomy is a most satisfactory operation in all those cases of ulcer of the duodenum in which there is actual or potential obstruction. We have followed Moynihan in infolding the ulcer with fine silk and placing one or two sutures in such manner as to block the pylorus to prevent food entering the ulcer-area during the healing period. This blockage by suture cannot be expected to be permanent, but in connection with the permanent obstruction produced by healing of the ulcer it usually answers the purpose. If there be neither actual nor potential obstruction, this blockage should be accomplished by more efficient means. We have used the fascia-closure of Wilms and the omental strip-closure of Kolb, in each case applying the living tissue to the groove previously made by the suture-blockage. Several of these patients were re-examined some time after the operation and the pylorus was found blocked.

At the present time we are excising a considerable percentage of duodenal ulcers when they are situated so that it may be readily done. In our earlier cases simple excision was practised and a certain percentage of them failed to obtain complete relief. It was found neces-

sary to make thorough provision for drainage at the pylorus after excision either by the Heinicke-Mikulicz pyloroplasty or, what we have found still better, the gastroduodenostomy of Finney, which lends itself admirably to the excision of the duodenal ulcer.

Results of Operation.—Duodenal and gastric ulcers at the pyloric end of the stomach yield equally good results following operation. The greater the distance of the gastric ulcer from the pylorus the greater the technical difficulties in its operative relief, the greater the mortality and, on account of the deformities which may be occasioned, the less certain the cure. But taking the patients as they come, at least 95 per cent. of those with gastric ulcer will be cured or greatly relieved by operation. The operative mortality in the gastric ulcers, counting all cases dying in the hospital without regard to length of time thereafter nor cause of death, was 3.8 per cent. This includes acute perforations, acute hemorrhages and all types of operations, resections, etc. The results in duodenal ulcer are extraordinarily good, 98 per cent. of the patients either being cured or greatly relieved by the operation. The mortality of this group was only 1.5 per cent.

Recurrence of Ulcer.—In a small percentage of the cases of both gastric and duodenal ulcers there has been a definite recurrence of symptoms and in which it would appear an actual redevelopment of the original ulcer had taken place. A small number of these patients have been reoperated on in our clinic and in each instance the source of trouble proved to be a gastrojejunal ulcer in the suture-line of the original gastrojejunostomy, as a rule due to the sloughing of the continuous sutures of silk or linen which had been used in the gastrojejunostomy. The symptoms were quite like those the patient was suffering from at the time of the primary operation, showing that the same disturbance may come from suture-ulceration as that manifested by the original lesion. We have, therefore, abandoned continuous silk sutures in gastrojejunostomy, now using interrupted musculoperitoneal sutures of fine silk with continuous chromic catgut for the inner rows.

Occasionally, fixation of the pyloric end of the stomach in the adhesions about an ulcer has continued to give rise to such pain and distress as to lead to the belief that the ulcer had recurred or, at least, to the idea that the operation was a failure. In these cases the unilateral pyloric exclusion of von Eiselsberg as a secondary operation has given permanent relief.

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ULCER OF THE STOMACH AND OF THE DUODENUM*

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I. Relative Frequency of Gastric and Duodenal Ulcer

Gastric ulcer described by Cruveilhier in 1830, from the point of view of pathological anatomy and the clinic, for a long time alone occupied the attention of physicians and surgeons. These knew well the acute peritonites resulting from perforation of duodenal ulcers, but this was almost the only point which interested them in the history of these ulcers.

In 1887, Bucquoy showed that, besides the perforation, a duodenal ulcer might declare itself by hemorrhages and even by simple dyspeptic troubles. A simple ulcer of the duodenum, he says, causes symptoms which, without having absolute pathognomonic value, have characteristics peculiar enough to permit us to make with a fair degree of certainty a diagnosis of the duodenal lesion. These symptoms are:

First, the intestinal hemorrhages, or melæna, occurring suddenly breaking out in the midst of apparently perfect health, and repeating themselves during several days with more or less intensity, so as to compromise seriously the lives of the patients. Often a melæna is accompanied or preceded by some hæmatemesis due to the regurgitation of the blood into the stomach.

Second, pain which, when it exists, which is the usual case, has for its location the zone underlying the lower surface of the liver, a little to the right of the median line, between the costal margin and the iliac crest. One may observe in duodenal ulcer the xiphoid and dorsal points belonging to simple ulcer of the stomach.

Third, digestive troubles, of which those most special to the malady are crises of pain often of extreme degree, accompanied or not by indigestion, which have the characteristic of manifesting themselves usually from three to four hours after the ingestion of food. The

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appetite is usually preserved and the disease develops in a general fashion by crises separated by intervals of good health.

Although the clinical recognition of duodenal ulcer may, therefore, be traced as far back as 1887, it is, however, just to recognize that until the labors of the English and American surgeons, especially Moynihan, duodenal ulcer was practically unknown to surgeons. For the last ten years, on the contrary, ulcer of the duodenum has occupied the front rank and our English and American colleagues attribute to it a considerable importance in the genesis of many dyspeptic troubles formerly commonly attributed to gastric ulcer. Indeed, it may be that duodenal ulcer is more frequent than gastric ulcer and its medico-surgical importance may be of the first rank.

Is this preponderance assigned to duodenal ulcer real, or have they not at the present time, on the contrary, given by a sort of seesaw play to duodenal ulcer, formerly not understood, an excessive importance? With the majority of the French surgeons we have thought that there is a manifest exaggeration in the present state of opinion. It is, indeed, true that we have for a long time failed to appreciate duodenal ulcers. Since our attention has been drawn to them by the English and American surgeons, we discover them from time to time, which otherwise we would have allowed to pass by. Notwithstanding this, in our statistical collections the frequency of ulcer of the duodenum remains much less with us than that of gastric ulcer, about one duodenal ulcer to eight or ten gastric ulcers. We are able to explain this difference between our figures and those of our American and English colleagues possibly in two ways: either duodenal ulcer is really more frequent in England and America, than in France, or our English and American colleagues make too readily the diagnosis of ulcer of the duodenum. The first explanation is, perhaps, correct. It is certain that food and mode of life play a very important role in the genesis of gastric and duodenal ulcers. The single fact that duodenal ulcer is relatively more frequent in men and gastric ulcer in women shows that there is something particular in the mechanism of the production of the two different kinds of ulcer. Ewald has noted that in the east of Germany hyperchlorhydria is more frequent than in the other sections of that Empire. It is then possible that duodenal ulcer is really more frequent in England and in the United States.

However that may be, one fact seems established, namely, that in France, at least, ulcer of the duodenum is much less frequent than ulcer of the stomach. Mathieu, making with great care a series of

autopsies with this special point in view, found four duodenal ulcers to 29 gastric ulcers. This figure agrees a little more nearly with that of the statistics, both anatomo-pathological and clinical, of Ewald, who finds 82 duodenal ulcers to 532 gastric ulcers. That is, one duodenal ulcer to from 6 to 7 gastric ulcers. One may, it is true, object that duodenal ulcer is often minute and may reveal itself at necropsy only under the form of an abrasion, or by a very small cicatrix visible among the mucous folds. This is a point upon which Codman insists. But it is the same with ulcers of the stomach and, if the abrasions or minute cicatrices of the duodenum do not figure in the statistics of Mathieu, neither do those of the stomach. We conclude therefore, contrary to current opinion, that according to the revelations of autopsies duodenal ulcer is much less frequent than gastric ulcer.

Do observations made in the course of operations warrant the affirmation as to the much greater frequency of duodenal ulcer? It is upon these principally that the English and American surgeons base their opinions.

Now what do they give as anatomical proofs of the existence of a duodenal ulcer *in vivo?* Often lesions of doubtful interpretation and slight roughness of the serous surface of the duodenum, a grayish plaque of cicatricial appearance. Sometimes even they have seen nothing and yet they affirm a duodenal ulcer. What seems to us the most important of these operative demonstrations is that, in the cases of duodenal ulcer accompanied with dyspeptic troubles for which surgical intervention has been done, the lesions found are always extremely near the pylorus. They are often so near it that to know whether they are above or below it our colleagues Moynihan and Mayo have fixed their exact situation by their relation to an anatomical landmark which they regard as very important, " the pyloric vein." Whatever is on the right of the vein is duodenal, whatever is on its left is pyloric. Now, this landmark is untrustworthy. The systematic researches of Latarjet, of Houdard and Mocquot have shown that the pyloric vein cannot be considered as an infallible guide. By his numerous researches our pupil, Houdard, comes to this conclusion that " nothing in the aspect of the veins of the region can enable one to recognize the seat of the pylorus and that the veins visible upon the anterior face of the pylo-duodenal segment without distinction, such as one sees in the course of an operation, cannot furnish a good surgical landmark at once easily recognizable and constant in its existence and in its location.

We arrive then at this conclusion that the demonstrations made in

the course of operations permit one to affirm only one thing; that is, that the lesions are situated in the immediate neighborhood of the pylorus which may be on the gastric or the duodenal side.

Can one make with certainty a preliminary diagnosis of ulcer of the duodenum? Moynihan thinks so and goes so far as to say that the diagnosis of duodenal ulcer can be made by correspondence. A story of late pain, a painful sensation of hunger relieved by the taking of food will suffice, according to his opinion, to determine the diagnosis. In reality, these symptoms far from being characteristic of duodenal ulcer are only one of the elements of the symptom-complex which one of us described in 1899 with Soupault, under the name of pyloric syndrome. They denote the existence of a pyloric spasm, whatever may be the cause of it. Pyloric spasm whether due to a gastric or duodenal ulcer gives these sensations of late pain coming on from three to four hours after meals, often at night, with a painful sensation of hunger relieved by the ingestion of some food. Sometimes this late pain is relieved by vomiting provoked. We have observed patients who, although presenting all the so-called characteristic signs of duodenal ulcer, in reality were the subjects of a gastric ulcer near the pylorus. Such was the case cited by one of us at the French Congress of Surgeons in 1910. The simple resection of a gastric ulcer near the pylorus without gastrostomy cured the patient. One may not suppose here that the symptoms were due to an unperceived duodenal ulcer, since there was no shifting of the alimentary circulation, and the patient was, nevertheless, completely cured. Finally, it is well to remember that these symptoms which are thought to be so characteristic may be wanting in cases of duodenal ulcer clearly established by operation, so that in an important statistical collection obtained from the practice of the surgeons of Edinburgh quite recently, one will find noted that out of 200 cases of perforated duodenal ulcers, in 17 there existed before the perforation no sign suggestive of the existence of such an ulcer (or 10 per cent.). In 55 instances of the 200 cases (quite 25 per cent.) the pre-existing dyspeptic troubles were very vague and in no case did there exist the symptoms supposedly characteristic of duodenal ulcer. These symptoms given as characteristics of the existence of a duodenal ulcer by the German and American authors are in our opinion purely and simply signs of pyloric spasm.

Bier in a recent memoir protested also against the ideas of Moynihan and based his opinion upon the analysis of 43 cases which he had observed in the course of the last 18 months. Leon Meunier, by a radio-

graphic examination made at the moment of a painful crisis in a patient suffering from an ulcer near the pylorus, demonstrated the reality of the pyloric spasm.

This idea of spasmodic contraction with pain and hypersecretion due to an ulcer near the pylorus is of the greatest practical importance, but it would be quite rash to affirm that all the troubles which this spasm produces are clinical symptoms characteristic of duodenal ulcer. Moreover, practically these discussions lose much of their interest since whether the ulcer is seated upon the gastric side or upon the duodenal side of the pyloric valve, the conduct of the surgeon will vary but little, as we shall see further on.

II. PATHOLOGICAL ANATOMY

1. *Gastric Ulcer.*—A recent ulcer of the stomach is rarely met with by the surgeon except in cases of perforation or in grave hemorrhage. Succeeding to an area of hemorrhagic necrosis of the gastric mucous membrane which has undergone at this point autodigestion, this ulceration may be difficult to discover in the living in the course of an operation. Sometimes nothing reveals it, neither to the sight nor to the touch. It is often necessary to incise the wall of the stomach and to examine with care the whole mucosa in order to discover the point of ulceration which is bleeding. These minute ulcerations of the mucosa, which Dieulafoy proposed to call "*exulceratio simplex*," are often very difficult to discover even on the autopsy table with the stomach open and spread out; notwithstanding these simple ulcerations may be the seat of a mortal hemorrhage. It is, justly, this considerable difficulty in discovering a gastric ulceration which so often renders unsatisfactory operations of urgency for grave hemorrhage.

The chronic ulcer that we meet much more often in the course of our operations may present itself in several different anatomical aspects.

a. Simple ulcer with borders moderately thickened reveals itself immediately to the view and to the touch. The serosa on its level presents always alterations due to chronic inflammation. It is œdematous, has lost its polish, is thickened, much congested, and with reddish spots disseminated through it. Its aspect differentiates it from the cancer plaque of the gastric wall seen from the side of the serous membrane. In cancer, the serosa in general is altered, but it has a whitish color, nowhere congested, and one sees often, with the naked eye, on its surface fine whitish lines or a network of yellowish points which correspond to the lesions of subserous cancerous lymphangitis. The neighbor-

ing lymphatic ganglia of the ulcer are sometimes increased in size, but if they are large, they remain relatively soft and movable and do not resemble, as a general rule, the cancerous adenopathy form of ganglia which are small and very hard.

Evidently these data furnished by simple macroscopic examination are not entirely free from criticism. They have only a relative value, but they can, nevertheless, permit us to differentiate at once an ulcer from a cancer of the stomach and in this respect they make, from the standpoint of pathological anatomy studied upon the living, a point of great interest to the surgeon.

The surgeon often meets, in the course of his work, ulcer partially healed by fibrous cicatrization. We say partially healed because it is always impossible to know by the simple macroscopic examination which one makes at the moment of the operation whether the cicatrization of the ulcer is complete. The contracted pylorus, the stomach made bilocular by an ulcer with a mesogastric location, have an appearance quite special to them which all surgeons are familiar with. Externally the gastric walls present a grayish white color. They are very hard to the touch and often by perigastric adhesions are joined to neighboring organs. It is impossible to know on account of all these lesions of cicatricial sclerosis whether the ulcer is really completely healed or whether it still presents some activity. This remark is important, we believe, for it appears to us to involve condemnation of operations which have the pretense of treating as definitely healed those ulcers which are only partially healed, such as the direct plastic operations, pyloroplasty or gastroplasty in which sutures are inserted into tissues incompletely sclerosed and still inflamed, in which cases observation has shown that there is great risk of failure.

The callous inveterate ulcer has as its anatomical characteristic a thickening, often very great, of its borders and a fibrous induration of its base. This ulcer has burrowed through the whole thickness of the gastric wall and its base is formed either by the inflamed and sclerosed epiploön, or by a neighboring organ which has been directly invaded, penetrated by the ulcer. One may give, then, the name of " penetrating " to those callous ulcers which penetrate into the pancreas, the liver or abdominal wall. When the ulcer is seated, as it frequently is, upon the small curvature of the stomach, it may remain relatively free and may penetrate only into the lesser omentum which becomes thickened and sclerosed. Upon complete sections of the callous ulcer of the lesser curvature one sees that the old gastric wall is destroyed

and that the base of the ulcer is formed by the sclerosed and thickened omentum. The borders of the ulcer in the gastric wall are very thick and present a very marked inflammation of all the tunics. The muscularis is infiltrated, sclerosed, and the mucosa exhibits often œdematous formations which may be polypoid in appearance.

The microscopical examination of the wall of these callous ulcers shows quite constantly grave alterations of the arteries and veins, endoperivascularitis often obliterating. These vascular lesions, primary or secondary, it is difficult to define, explain the poor nutrition of the tissues forming the base and the borders of the ulcers and the little tendency to heal which is a characteristic of these callous ulcers. We have many times found in the walls of these callous ulcers of the lesser curvature the lesions of neuritis and alterations of the small nervous ganglia situated in the tunics of the sclerosed muscular walls. These alterations upon which Loeper has recently insisted are interesting and may explain the persistent pain which is often a predominating symptom of non-stenosing callous ulcers.

From the operative standpoint, the idea of a callous ulcer penetrating into an organ, such as the pancreas or liver, is important and we shall have to insist upon it again when we shall speak of the treatment of these ulcers. Suffice it to say for the moment that this penetration of the ulcer into a neighboring organ, although it complicates seriously the intervention, is not, however, a sufficient reason for causing excision of these ulcers to be rejected. To the naked eye the diagnosis between a callous ulcer, whether penetrating or not, and a cancer of the stomach wall is always difficult. It is chiefly the œdema and the notable congestion of the neighboring tissues and the absence of, especially, the inflammatory complications of neighboring glands which enables us up to a certain point to differentiate with the naked eye ulcer from cancer. We attach no value on our part to examinations made extemporaneously by frozen sections. This technic which may appear very modern and very elegant is really a snare, for in the doubtful and difficult cases, the only ones important in this class, the rapid examination of a few sections hastily stained can give no certainty. Reliance must then be based upon the macroscopical examination and upon the previous clinical study of the living patient.

2. *Cancer Ulcer.*—The transformation of the chronic ulcer into cancer, or, better, the development of cancer upon the borders of an old callous ulcer, gives a question still under study and very differently

answered by authors. Some such as Wilson and MacCarty, examining the specimens furnished by the Mayo clinic, estimate that 71 per cent. of the callous ulcers of the stomach present lesions of cancerous development. Others, more reserved, assign only 10 per cent. as the average frequency of a cancerous degeneration of gastric ulcers.

Without going so far with certain authors as to deny the existence of ulcero-cancer, which would be too radical, we think, nevertheless, that the development of a cancer upon a chronic ulcer of the stomach is rarer than certain recent authors consider it to be. Hayem and Lion out of 94 gastric cancers studied completely from the point of pathological anatomy have found 21 cases of ulcero-cancer, being about 20 per cent. Upon 14 specimens of resected callous ulcer we have three times found cancerous degeneration in the borders of the ulcer, the base of the ulcer remaining free from the neoplastic invasion, also about one-fifth. In 10 other specimens which could be interpreted macroscopically cancers, because of the deep white central ulceration with elevated and thickened borders, we have found diffuse cancer lesions both at the base of the ulcer as well as upon its borders. We think that it is impossible in these cases to say that they were ulcero-cancer rather than ulcerated cancer. It should be added further that practically the diagnosis of ulcero-cancer should be based quite as much upon the complete clinical history of the patient as upon the simple examination of the pathological specimens.

3. *State of the Gastric Mucosa at a Distance from the Ulcer.*— We have often taken away, in the course of gastro-enterostomies done for gastric ulcer near the pylorus, fragments of the gastric mucous membrane. These fragments have always been taken at the same point, that is to say at the level of the most dependent portion of the pyloric antrum, the point where we make the gastro-intestinal opening. Of 30 fragments of mucosa thus taken away we have found 25 times the lesions of gastritis; sometimes hyperplastic parenchymatous gastritis with multiplication of the principal follicles, sometimes mixed gastritis characterized by a small follicular lesion which is due to an interstitial reaction, evidenced by infiltration with embryonic cells, or an abnormal abundance of lymphoid tissue in the mucosa.

Such frequent existence in connection with ulcers of the lesions of gastritis, which have been so well described by Hayem and Lion whose nomenclature we adopt, is interesting to be noted by the surgeon. They show us, in fact, that in the surgical treatment of gastric ulcer one should never forget that one has to do with a gastric mucosa most

frequently altered in its entire extent; whence, as a logical consequence, the importance of post-operative medical treatment which should be continued a long time in ulcer patients who have been operated, if one wishes to obtain permanent success.

III. CLINICAL STUDY

The clinical signs of ulcer of the stomach and of the duodenum are generally well known. We mention simply the importance of alimentary stasis in the early morning as a sign of stenosis, that of blood, even in small quantity, possibly discoverable only by chemical research, as a sign of ulcers in process of development and we shall insist simply upon the symptoms which sometimes permit us to diagnosticate the seat of these ulcers.

1. *Ulcers Near the Pylorus.*—Their symptoms are those which have been attributed by Moynihan to ulcers of the duodenum. We have set them forth above and consequently will not return to them now, as we have already said it seems to us impossible by a simple analysis to say whether the ulcer is seated upon the gastric or duodenal side of the pylorus.

Meunier has, however, pointed out recently a process which will permit of localization of an ulcer. This is as follows: After having emptied and washed the stomach, one makes a second washing with 200 grammes of 1 per cent. solution of glacial acetic acid. When this solution comes in contact with the pylorus, the pylorus closes and the duodenum cannot be bathed by this liquid. The acetic acid solution dissolves the crystals to hæmatin which exist upon the surface of the ulcer however small it may be. One seeks later in the liquid extracted through the tube, blood by the usual chemical process. The reaction is positive, if there is a gastric ulcer present, negative, if the ulcer is seated in the duodenum.

2. *Ulcers of the Lesser Curvature.*—Their symptomatology has been carefully studied by Loeper and Schulmann. Pain is an essential element of the syndrome presented by ulcer of the lesser curvature. This pain follows close upon the ingestion of food; it persists sometimes during the entire process of digestion, but becomes lessened generally at the end of an hour. It is a very severe pain presenting suffering which radiates from the epigastric notch to the base of the thorax under the sternum and the ribs of the left side. Palpation of these regions reawakens the pain. Vomiting is frequent; it is often early,

clear, with mucus and threads, suggesting the saliva in its aspect. Nausea which is rare in ordinary ulcer of the stomach, is constant in ulcer of the smaller curvature. This nausea may persist even without respect to meals during several weeks. Early ptyalism coming on half an hour after the meal is often prolonged beyond the pain. This ptyalism provokes spitting or fear of saliva and of air. One observes frequently in patients attacked with ulcer of the lesser curvature circulatory troubles, bradycardia, lessened arterial tension. The oculo-cardiac reflex of Ashner and Miloslavich, that is to say, the slowing of the heart under the influence of the compression of the two eyeballs, may be met with, exaggerated in patients attacked with ulcer of the lesser curvature. This phenomenon may be due to a latent irritation of the pneumogastric nerve, quite explicable in those patients whose ulcer irritates the inflamed nervous filaments of the gastric wall. We have already spoken of the lesions met with in the walls of callous ulcers of the lesser curvature.

3. *True Duodenal Ulcer.*—Under the name of true duodenal ulcer, Mathieu has described the ulcers seated upon the duodenum at a distance sufficiently great from the pylorus to ensure that the pylorus is neither involved in the ulceration nor invaded by a peri-ulcerous inflammatory process which may give rise to the phenomena of spasmodic stenosis of reflex origin. This true doudenal ulcer is rare, according to Mathieu, it is met only in the proportion of 1 to 10 as regards gastric ulcers. Men are much more often attacked than women, 75 per cent. of men. This duodenal ulcer progresses by paroxysmal attacks more or less prolonged, separated by intervals of calm of variable duration. The general symptoms of this ulcer are both of the pain and the bleedings, as Bucquoy has already pointed out, the pain of variable intensity coming on generally three or four hours after the meal, seated sometimes in the epigastrium and sometimes more frequently in the hypochondrium, whence it radiates to the base of the thorax. The pain may be provoked or made worse by palpation of the abdominal wall to the right of the median line. The pain is often relieved in the beginning of the malady by the ingestion of food, but this phenomenon follows no longer in the more advanced evolution of the ulcer, and at the same time the hour for the pain becomes more irregular, then ceases to be noticeable. Hemorrhages manifest themselves especially under the form of melæna of variable intensity, coming often in the midst of apparent health and sometimes entailing profound anæmia. When true duodenal ulcer is not accompanied by cicatricial

stenosis, which is most frequently the case, there exists none of the phenomena of gastric retention (early alimentary stasis). These symptoms are not very characteristic. If they should occur and be well marked, the existence of a duodenal ulcer may be seriously suspected.

4. *X-ray Examinations.*—The X-ray examination has become a necessary complement to the purely clinical examination. This examination should always begin by a radioscopic study of the stomach. This gives us general information as to the form of the stomach, its mobility, upon the site of points painful to pressure, upon its method of emptying itself. It also enables us to distinguish from true bilocular stomach certain false biloculations which one observes quite frequently in prolapsed stomachs.

Thus, as Leven and Barret have well shown, it is sufficient to press in these cases upon the lower part of the organ in order to see the contracted part expand and demonstrate thus the absence of true mediogastric stenosis. Radiography only enables us to preserve the image of certain pathological alterations which one must study further. Contrary to cancer, whose presence is revealed by the existence of a gap-like image, ulcer, so far from making any projection into the cavity of the organ and there displacing the ingested bismuth, creases rather the gastric wall and may betray itself by a dark stain, its cavity being filled with bismuth. These stains upon the gastric wall are, however, only rarely detected and have no great practical importance. On the contrary, the diverticular recesses (notches) of the gastric wall, described by Haudeck, have considerable importance. We have seen them many times with the greatest clearness and operation has verified in these cases the existence of a deep ulcer invading the gastric wall, or a penetrating ulcer. To see these notches of Haudeck it is sometimes necessary to examine the patient in profile, the shadow thrown by the bismuth being able to mask that of a diverticulum which would not appear well marked except in an oblique position. The aëro-bismuth diverticulum of Haudeck characterized by a light stain superimposed upon the dark stain of the diverticulum, is characteristic of ulcers penetrating into a neighboring organ. In order to avoid errors, it is necessary to take care to mobilize the stomach while the patient is before the screen. One may determine thus the fixedness of the diverticular recess and often, also, one may observe that there exists a fixed painful point corresponding exactly to the seat of the diverticulum.

As to ulcer of the duodenum, we have never observed stain nor recess visible by radioscopy. Besides, it is admitted by those who have the most experience in these examinations with the screen that radiographic examination of duodenal ulcers is difficult. Holzknecht has recommended to inject bismuth directly into the duodenum by means of a tube and to compress afterwards with a special tampon the duodenojejunal angle. This delicate manœuvre complicates very much the examination with a screen and increases proportionately the chances of error.

The form of the stomach may be modified by the presence of an ulcer, so that with respect to an ulcer of the lesser curvature there may exist a spasm of the opposite gastric wall which will give on the screen the appearance of gastric biloculation really non-existent. Methodical palpation of the stomach during the examination will enable us sometimes to recognize that this biloculation is only intermittent, or is easily overcome. It is well to note that there are sometimes persistent spasms which produce a real bilocular stomach.

The true bilocular stomach due to mediogastric stenosis following ulceration may usually easily be recognized on the screen. In the most typical cases one sees the two pockets, cardiac and pyloric, unequally filled with bismuth and separated by a canaliculated zone of fixed constant dimensions. It is not very rare to see the recess of Haudeck at the level of the contracted zone. Generally the canal which joins the two pockets lies near the lesser curvature. When a mediogastric stenosis is close, the bismuth remains a certain time in the upper pocket, it appears as a small sac hung below the diaphragm, then the bismuth descends slowly into the inferior pocket.

Close pyloric stenosis produces a total dilatation of the stomach with deformity of the normal shadow of this viscus. There is, in fact, a considerable enlargement of the organ in its transverse diameter; the shadow in enlarging extending to the right of the median line, well limited below, surmounted by a grayish zone (the intermediary layer of Béclère). This zone corresponds to the presence of retained liquid which separates the bismuth shadow from that portion of the pocket filled with air, always situated in the upper part of the stomach. Often in these cases of great gastric dilatation the bismuth shadow does not rise as far as the pylorus which remains invisible.

In certain callous ulcers of the lesser curvature one may see a kind of folding together of this region which deforms the stomach, bringing together the cardia and the pylorus.

Extensive perigastric adhesions (adhesive perigastritis) may sometimes declare themselves upon the screen by the immobility of a more or less extended portion of the organ, or by the appearance of the bismuth shadow which, in place of being regular, presents an irregular appearance.

The modifications of the motility of the stomach due to an ulcer, active or cicatrized, may also be observed in certain cases by radioscopic examination.

When the pylorus is contracted or in a state of spasm, but still permeable, there exists an exaggeration of the peristaltic movements of the stomach. The pylorus is much contracted, the stomach dilates transversely and the evacuation of the bismuth emulsion is extremely slow notwithstanding the exaggeration of the peristalsis. In certain cases antiperistalsis is produced, the recurring waves moving in a direction opposite to the normal and alternating without regularity.

German authors incline to admit that generally in gastric ulcer the passage of bismuth is slow and that, on the contrary, in true duodenal ulcer it is accelerated. One can verify especially well these phenomena by having the patient swallow a small quantity of a solution of hydrochloric acid, 5 to 1000. This phenomenon is explained by pyloric spasm which exists almost always in gastric ulcer and is wanting, on the contrary, often in true duodenal ulcer.

Finally, it is necessary to add that radioscopy in permitting us to control the results of operations upon the stomach and duodenum has rendered inestimable services of which it is wise never to deprive one's self.

IV. SURGICAL TREATMENT

A. Treatment of Complicated Gastric and Duodenal Ulcer.—1. *Perforation.*—It is useless to insist upon the absolute necessity for the most rapid possible surgical treatment in cases of perforating gastric or duodenal ulcer. It is known that perforation may take place into the free peritoneal cavity, or, on the contrary, into a peritoneal zone already protected by adhesions. In the first case, rapidly progressive diffuse peritonitis is inevitable, to combat which it is necessary above all things to thoroughly close the perforation. According to the case, one will practise excision of the perforated ulcer, followed by suture in two planes to the loss of substance in the parietes of the stomach or simply an infolding of the perforated ulcer when excision may appear impossible or too difficult. Plastic use of the epiploön may be serviceable in these cases to reinforce a doubtful suture. Simple damming by

a tamponade of gauze around the perforated zone with drainage is only a *dernier resort,* which should be resorted to only in cases of absolute necessity. This proceeding, however, has enabled us to save a patient whose perforation, very highly situated, was almost inaccessible.

When the general state of the patient will permit it, an immediate posterior gastro-enterostomy appears to us to be good practice. One of us (Lecene) has practised it 4 times with 4 successes. This complementary gastro-enterostomy is above all indicated when the perforated ulcer occupies the pyloric or duodenal region, for sutures then often produce constriction at the region near the pylorus.

Treatment of the peritonitis itself will be instituted according to the rules accepted to-day by the majority of surgeons: suprapubic drainage by a small special incision; immediate closure of the abdominal wall to the level of the epigastric region, the sitting position of the patient in his bed the back sustained by a rest and the head of the bed raised, enteroclysis in salt solution in large quantity. This is, in fact, the American method for the treatment of acute peritonitis applied to the treatment of perforations of the stomach and of the duodenum. Lavage of the peritoneal serous surface as a part of the operation does not appear to us to be indicated in all cases. This lavage seems to us to be necessary only to remove mechanically food masses sometimes met with in the seropurulent exudate of the peritoneal cavity. In these cases, as in all other cases of peritonitis from perforation, the great factor of success is early intervention. This all statistics show.

Of 202 operations for peritonitis from perforating ulcer of the stomach, that we have gathered, we find that of 96 operations done in the first 12 hours, 38 deaths resulted (39 per cent.); of 64 operations done between 12 and 24 hours, 35 deaths (56 per cent.); of 42 operations done between 24 and 58 hours, 34 died (81 per cent.).

When perforation has taken place into an area already protected by adhesions, there is produced, as a general rule, a subphrenic abscess. Of 890 cases of subphrenic abscess, collected by Piquand, in 234 cases the cause of the suppuration was a gastric ulcer which in 191 instances was seated near the pylorus, and in 36 cases there was present a perforated duodenal ulcer. Incision of the subphrenic abscess follows naturally as soon as the diagnosis is established. The evacuation of the pus may often suffice to bring about cure, but a grave complication may be noted once the abscess cavity is evacuated and drained, that is the formation of a fistula opening into the stomach or the duodenum.

When this evil complication occurs the life of the patient is seriously threatened; if the food escapes externally in abundance, death from inanition supervenes. These cases are happily rare. When the fistula connects with the duodenum, it is better to practise a gastro-enterostomy with exclusion of the pylorus, as Berg, Moynihan and Knaggs have done. If it is the stomach itself which is involved, the course to pursue is more delicate. It seems in these cases it would be well to attempt resection of the perforated gastric wall or to do an immediate suture, notwithstanding the risk of having the suture fall, or one could make a jejunostomy.

2. *Hemorrhages.*—Hemorrhage may be considered as a complication of gastric or duodenal ulcer only if it is very abundant, or if it is often repeated. In case of large hemorrhage coming on abruptly, the surgeon should restrain himself, as one of us has already expressed it in 1902. In fact, if, theoretically, the indication to ligate the bleeding point is clear, practically its performance is attended with much difficulty. The opening of the stomach and the minute exploration of the mucous surface of the organ constitute a complex surgical interference which can only be born by an individual of great resisting power. A bleeding erosion may be difficult, or even impossible, to discover during life. An ulcer may be accompanied with such infiltration and such friability of the neighboring tissues that the placing of a reliable ligature is impossible. So much for the reasons which militate against the immediate intervention in a patient in a state of shock and acute anæmia.

The results of interventions which have been attempted in these cases have, moreover, been very bad: 25 deaths in 42 patients, *i.e.*, 64.2 per cent., according to the statistics of Mayo-Robson. This figure agrees with our own statistics together with those of Mikulicz and of Czerny (63 per cent.). Death, moreover, supervenes only in exceptional cases, when the patient is immediately immobilized and put on an absolute diet. It has occurred to us to see patients get well, who had become blanched by such bleeding.

On the other hand, when the hemorrhages are repeated and provoke a profound state of progressive anæmia, surgical intervention is indicated. There should be made on the preceding day, or followed immediately by, a blood transfusion which in such cases finds the happiest indications. The character of the intervention will vary according to the situation of the ulcer. If this is at the pylorus and provokes signs of stenosis, gastro-enterostomy gives often good results

and appears to us to be the operation of choice. It suppresses the contractions of the stomach made violent by the exaggeration of the habitual peristalsis in such cases and in a large measure will place the stomach at rest, whereby the formation of a clot is favored.

If the ulcer is plainly duodenal, gastro-enterostomy completed by pyloric exclusion is very rational and has given good results. When the ulcer is gastric, but is not seated near the pylorus and does not produce the accidents of stenosis, gastro-enterostomy produces little or no influence upon hemorrhage. One can have recourse in such cases to ligature of the vessels in the neighborhood of the ulcer; in a case of pronounced anæmia consecutive to repeated hemorrhages which originated in a callous ulcer of the lesser curvature, we have ligated the gastric coronary artery and the pyloric artery and had the patient recover. When the state of the patient may permit a more serious interference one may resort with advantage to excision of the ulcer followed or not by a gastro-enterostomy.

Jejunostomy which secures an absolute rest of the stomach and of the duodenum has been done in these cases (Eiselsberg, Moynihan, Loyal).

Personally, we have no experience in jejunostomy practised for this particular indication.

3. *Cicatricial Stenoses.*—In stenosis of the pylorus consecutive to cicatrization of an ulcer, a pyloroplasty has been advised. Even with the modification of Finney, pyloroplasty does not appear to us to be a method of interference to be recommended rather than gastro-duodenostomy. Theoretically, it has certainly some advantages, but in our opinion it has a capital fault: the intervention is made too near the diseased region near which there may still exist ulcerating lesions undergoing development. This operative method has also the inconvenience that it does not exclude the alimentary circulation from the duodenum, which can still be the seat of an active ulcer below the point where the operation is done. Personally we have never had recourse to a pyloroplasty and we have always contented ourselves with gastro-enterostomy, the results of which are excellent and give to patients, the subjects of pyloric stenosis from ulcer, practical resurrection. In a single case we have regretted not having done at the same time as the gastro-enterostomy an excision of the pyloric region; this was in a patient suffering from a callous ulcer stenosing the pylorus, upon whom we did a gastro-enterostomy, in November, 1899. After four years of perfect health this patient died of a gastric cancer. It

is evident that this patient would have been benefited by a pylorectomy at the first operation. We have resorted to pylorectomy in many other cases of pyloric callous ulcer. We advise this method of proceeding for this particular condition. One point to which we desire to call attention is that in these pylorectomies for ulcer, it may be dangerous to finish the operation by a duodenogastric implantation, after the method of Kocher. The pyloric ulcerous lesion may, in fact, be accompanied by an analogous lesion in the duodenum, and this is not excluded from the alimentary tract. One of our patients, after a pylorectomy followed by a duodenogastric implantation, has succumbed from a very great bilious regurgitation which we were not able to explain to our satisfaction. At the autopsy we found present below the ampulla of Vater, an ulcerous stricture of the duodenum which we had overlooked at the time of the resection of the callous ulcer of the pylorus. So we think that in these pylorectomies for ulcer gastro-enterostomy with closure of the two ends is to be preferred to duodenogastric implantation. Though indicated in callous ulcers, pylorectomy is unfortunately not always technically possible because of extensive adhesions and inflammatory conditions in neighboring organs. It has been suggested, in such case, to resort to exclusion of the pyloric region (Eiselsberg). We have never personally practised exclusion of the pylorus in these cases. Exclusion of the pylorus does not protect a callous ulcer from secondary cancerous degeneration which is, indeed, the great danger of the future, so that this method of operating does not seem to us very rational.

Stenosis of the duodenum by cicatrization of an ulcer, much more rare than pyloric stenosis, seems to us to call for the same treatment, gastro-enterostomy. Duodenoplasty, an operation technically difficult and uncertain as to the future, appears to us still less to be recommended than does pyloroplasty.

Mesogastric stenosis by ulcer giving rise to the well-known hour-glass deformity calls strongly for surgical treatment. Numerous procedures have been recommended for the surgical treatment of bilocular stomach. It is, however, certain that there is no one procedure applicable to all cases, so that one must be governed in each case in his choice of procedure by the anatomical conditions. If mesogastric stenosis is not accompanied by pyloric stenosis, and, if the ulcerous lesions have not provoked about the affected area too extensive adhesions to neighboring organs, it seems to us that the most satisfactory operation and the surest is partial resection of the stomach followed

by end-to-end anastomosis of the two gastric segments. When it is possible such partial gastrectomy is in these cases a very good operation, giving perfect functional results; we have resorted to it three times with excellent result.

But when pyloric stenosis coexists (which is rarely), or when adhesions around the contraction are such that partial gastrectomy is impossible, it is necessary to resort to other methods. It has been proposed in such cases to make a gastroplasty, an operation based upon the ancient pyloroplasty, a longitudinal section of the stenosed zone sutured vertically. It is a bad operation which has given numerous failures. This method has the very grave fault of placing the sutures in the area of diseased tissue and it is open to the same objections as pyloroplasty. In one of our patients this gastroplasty which appeared to have given an immediate satisfactory result was followed by recurrence and we had to reoperate. Gastroplasty should, then, be rejected. A wide anastomosis between the two pockets, cardiac and pyloric, always supposing the presence of a normal pylorus, is an operation much more satisfactory when it is anatomically possible. That is to say, when the two pockets, cardiac and pyloric, are sufficiently large and sufficiently mobilizable to permit suture without traction. Such gastrostomy is a good operation which has given us successful results and which we recommend.

When the pylorus is contracted, none of the operations of which we have just spoken are possible. It is necessary then to have recourse to gastro-enterostomy practised upon the cardiac pocket when it is large, the pyloric pocket being small. Gastro-enterostomy has given us in such cases very good results. When the pyloric pocket is quite large, a two-fold gastro-enterostomy may be done, the one upon the cardiac and the other upon the pyloric pocket.

4. *Perigastritis.*—It is not exceptional to meet with patients who have presented signs of gastric ulcer and who, notwithstanding the healing of their ulcer, continue to suffer from the lesions of perigastritis. In these cases surgical treatment may be indicated. When the adhesion which unites the stomach to neighboring organs, as the liver, diaphragm, abdominal wall, is limited, and when the gastric ulcer appears well healed, the simple section of the adhesion has given success; but when diffuse adhesions exist, or when a gastric ulcer is still active, such gastrolysis is an operation which is accompanied by numerous difficulties. The liberation of the adhesions is in these cases very often followed by reproduction of the same adhesions. To hinder the ad-

hesions from reforming there have been employed iodoformized vaseline, the oil of vaseline, olive oil and liquid lanoline. It is impossible, really, to pronounce upon the value of these procedures which have been employed upon the living patients. Mayo-Robson has proposed to insert between the bleeding surfaces the free border of the great omentum; one can quickly make in such cases a true epiploöplasty; we think that an accurate hæmostasis and a very exact covering with peritoneum for the bleeding surface makes the best means we have had at our disposal for hindering as far as possible reproduction of liberated adhesions. If simple gastrolysis has failed, it has been proposed to add to it either a gastro-enterostomy or an excision of the zone where the ulcer was seated. In one patient gastrolysis and gastro-enterostomy practised at the same time gave us a result at first favorable, only to be followed by a reappearance of trouble. The patient presented a new alimentary stasis and the operative result was incomplete. This fact shows how necessary it is to be conservative in one's judgment of the results of the operations for extensive adhesive perigastritis by which the stomach has been deformed and its functions seriously interfered with. One can understand how, in the presence of repeated failures in certain cases of extensive perigastritis, some surgeons advise recourse to extensive gastric resection.

5. *Ulcers Which Have Undergone Cancerous Degeneration.*—We do not speak of ulcerated cancers; the therapeutic indications are the same as in any case of cancer of the stomach whether or not following upon an ulcer.

B. Treatment of Non-complicated Gastric and Duodenal Ulcer.—1. *Gastric Ulcers and Duodenal Ulcers with a Pyloric Syndrome.*—The operative indication seems to us to be the same in all ulcers situated in the vicinity of the pylorus whether they are seated in the stomach or in the duodenum, when these ulcers are accompanied by a pyloric syndrome and they have proved resistant to medical treatment. Clinically, as we have already said, it does not appear to us possible to make a differential diagnosis between gastric pyloric ulcer and duodenal ulcer.

Surgical intervention will begin always by a careful exploration of the whole pyloric and duodenal region, whereby the exact seat of the ulcer is determined. When it is possible, we practise the operation which appears to us to be much the most simple and the most certain, namely, gastrojejunostomy. We do it posteriorly through the mesocolon with a very short jejunal loop. We attach very great importance

to placing the gastric orifice of the anastomotic opening upon the pyloric antrum itself at its most dependent point quite near the great curvature. We always employ sutures; never the anastomotic button. The sutures, silk or linen, are arranged in two planes, the deep suture, including the whole of the gastric and intestinal tunics, is at the same time occlusive and hæmostatic; the superficial suture, seromuscular, covers in completely the deep suture and protects it. We never use clamps and we open the visceral cavities with the bistoury, seeking to make clean incisions. We think it is very important to observe these technical details in order to avoid the formation of secondary peptic ulcers at the orifice of communication or within the jejunum. It is quite certain that persistent hyperchlorhydria plays a primordial role in the genesis of this grave complication of gastrojejunostomies, but its action seems to us facilitated by every traumatism of the gastric and intestinal walls in the course of the operation.

It has been said that the gastro-enterostomy does not act as a mouth as long as the pylorus is permeable. Some have even gone further and have claimed that the mouth not only does not functionate, but contracts, and finally becomes obliterated. We cannot agree with such assertions. A gastro-intestinal orifice well covered with mucous membrane without cicatricial tissue, cannot become obliterated even if nothing passes through it. Such obliteration would be contrary to the laws of general anatomy and we are surprised that such an error has been advocated. Careful analysis of the published cases of obliteration shows besides, as Hartmann has established, that these obliterations are due to the development of ulcerative processes affecting the borders of the anastomotic mouth, followed by cicatricial stenosis. They have been observed as well in cases of pyloric stenosis as in those of permeable pylorus. There is no longer any dispute possible upon this question.

As to the physiological failure of the gastro-enterostomy mouth to functionate in cases of permeable pylorus, it would seem to have been established by the experiments of Kelling, in Germany, and of Delbet, in France. These authors have not in our opinion taken sufficiently into account in their experiments the exact anatomic seat of the anastomotic mouth. The stomach may physiologically be considered to be formed of two portions, the cardiac and pyloric portions. The latter is essentially the motor part of the organ. When the gastro-enterostomy opening is established upon the cardiac portion, which in the dog is the part that immediately presents to the operator, the largest part of the

gastric contents is, in fact, evacuated through the pylorus. When, on the contrary, one takes care to make the anastomosis upon the pyloric antrum, the gastric contents pass almost entirely by the anastomotic opening. This is shown by experiments, as yet unpublished, upon the dog by Hartmann and Métivet.

Radioscopic observations made upon our old patients by our former interne, Wolfrom, have established that this is so, also, in man. Upon a series of patients upon whom we have done a gastro-enterostomy, and who presented before the operation neither stenosis nor alimentary stasis, Wolfrom has been able to show that the bismuth mixture passed almost immediately after its ingestion through the gastrojejunal opening; after only a certain time a small quantity of the bismuth found its way through the pylorus. The proper conclusion from this is that we should systematically make the anastomotic opening upon the pyloric antrum.

In cases of ulcer seated clearly upon the duodenum, we have never practised true exclusion of the pylorus by division and obliteration of the two ends. In some cases only, we have retrenched the pylorus by plicating it vertically according to the procedure of Doyen, praised by Wm. Mayo and termed by him "blockage," this blocking sufficing to hinder all passage from the stomach into the duodenum, as we have determined in an autopsy.

The pyloric exclusion is counselled by a certain number of surgeons and there have been devised for its practice numerous procedures. Blockage of the pylorus has been, as we have just said, advised by Doyen in 1893. Here is what Doyen wrote at that time: "We invaginate with the finger into the duodenum a small part of the walls of the stomach which we fix by three or four points of suture. We fill up, thus, the pylorus from in front by this small invagination, suturing its inferior and superior borders together by a longitudinal suture, either continuous or interrupted."

This process of blockage may give us the results sought for, as we have said. It is simple and rapid. It seems to us easier than the submucous process of Girard (1911). This is an inverted pyloroplasty. A vertical incision is made on the face of the pylorus not involving the mucosa; the lips of this incision are dissected up and the wound in the gastric wall is sutured horizontally, having been transformed into a lozenge shape by horizontal traction. Complete exclusion of the pylorus can be realized with absolute certainty only by the complete resection of the pyloric antrum of the stomach followed by a closing suture of each

cut end. We think that the simple blockage may very often be sufficient for the physiological exclusion of the pylorus; if one wishes, on the contrary, to obtain positive exclusion, it is to the procedure of complete section followed by a closure of each cut end that recourse must be had; but such complete exclusion thus done has the inconvenience of prolonging notably the operation and seems to us to be recommended only in cases of very positive indication.

2. *Duodenal Ulcers.*—As we have already said, we think that, as a general rule, gastro-enterostomy followed, or not, by a simple blockage of the pylorus, or a complete exclusion according to the case, suffices to ensure the complete evacuation of the stomach and to set at rest a duodenal ulcer. Is it necessary in certain cases to have recourse to excision of the duodenal ulcer with or without consecutive duodenoplasty? Jaboulay made formerly this excision with duodenoplasty. Wm. J. Mayo has also done a large number of such excisions of the duodenal ulcer (52 times) without gastro-enterostomy. The results have been very good, both immediate and later.

This excision of the duodenal ulcer does not appear to us, in general, to be much indicated. It complicates notably the intervention and it does not appear evident that it gives better results than simple gastro-enterostomy with exclusion of the pylorus. However, if the duodenal ulcer is very easily accessible, and above all if a perforation seems imminent, excision may be resorted to, and yet, in such cases, would it not be better to bury widely the ulcer by infolding the duodenal wall? Our personal experience is not sufficient to enable us to decide upon this point.

3. *Non-pyloric Gastric Ulcers.*—When the gastric ulcer is seated some distance from the pylorus, a simple posterior gastro-enterostomy may still give good results. It seems, indeed, that it especially acts in such cases through a partial neutralization of the gastric acidity, due to the flow of the bile and the pancreatic juice into the stomach. The slight reflex into the stomach of the jejunal contents, which one observes constantly after gastro-enterostomies, far from being injurious to the patients, constitutes, on the contrary, one of the elements of success of the operation.

It is, however, proper to recognize that gastro-enterostomy does not give constantly favorable results when the ulcer is seated a certain distance from the pylorus. Thus, in one of our patients upon whom gastro-enterostomy was done in 1908, all trouble disappeared for two years and the patient increased in weight, 15 kilogrammes. Then the

pains reappeared, at first slight, then more and more severe until in July, 1913, the patient presented herself again emaciated and suffering much, and the radiograph demonstrated clearly an ulcer of the small curvature with the notch of Haudeck. The gastrojejunal mouth was working well.

The failures of gastro-enterostomy are specially frequent in cases of callous or penetrating ulcers which occupy by preference the small curvature or the posterior face of the stomach. It is in this class of cases that excision of the ulcer presents itself for consideration. This ablation of the ulcer appears so much the more indicated in rebellious callous ulcers which are those that present quite often lesions of secondary cancerous degeneration.

We have never practised excision of the ulcer by the transgastric path which has been done a certain number of times by W. J. Mayo. The only operations to which we have had recourse have been the excision of ulcer of the lesser curvature, partial resection of the stomach with terminal anastomosis and partial gastrectomy with closure of the two cut segments, and gastro-enterostomy.

The great reproach which has been made against this excision of ulcers, of gastric resections for callous ulcers, is that they are followed by a great mortality. This is, in fact, at least 10 per cent. Payr, who has recently, in Germany, with Riedel and Küttner defended these gastric resections for callous ulcers, found 10 per cent. of mortality out of a total number of 465 cases of excision or of resection for ulcer collected in the literature. The personal statistics of Payr were 2 deaths in 30 cases; the Brothers Mayo have had to deplore only two deaths in 78 operations, 38 excisions and 40 resections. This showing is particularly favorable. One may then hope that as the technic is perfected, there may be reached a notable lowering of the mortality of these resections for ulcer. What the operative technic shall be is then of major importance. It will naturally vary according to the case.

Simple excision of the ulcer and its thickened borders to a sufficient extent, followed by suture of the stomach, is to be recommended only if the ulcer is neither too extensive nor too adherent and especially when it occupies a region of the stomach easily accessible, as, for example, the anterior face of the organ or the great curvature, but we know that these are exceptional points of localization for gastric ulcer, above all when it presents the anatomical form called callous ulcer. After these simple excisions it is then wise to make a complementary gastro-enterostomy, for one may have left behind a small ulcer little visible

and it is always indicated to drain the stomach and to place that organ at rest.

When the callous ulcer is seated at the level of the lesser curvature, a frequent occurrence, two conditions may present themselves practically, either the callous ulcer is little adherent, simply accompanied by sclero-œdematous infiltration of the lesser epiploön, the stomach remaining movable, or the stomach adheres posteriorly, presenting the anatomical type described as penetrating ulcer. In the first case, when the stomach after careful exploration of the postomental cavity by invagination of the gastrocolic ligament can be well mobilized and drawn out, one can practise saddle-shaped resection of the lesser curvature. This operation in cases where it is anatomically practical gives a very good immediate anatomical result. My experience has shown that it is capable of giving lasting functional results. The only precaution to take in these cases is to make a satisfactory suture, performing, indeed, a true gastrogastrostomy between the segments. It is the only way to avoid considerable malformation of the stomach, which would be produced by any other kind of suture of the gastric breech created by saddle-shaped excision of the lesser curvature.

When, on the contrary, callous ulcer is of the penetrating type, or when it is firmly adherent behind the stomach and cannot be drawn out, it is quite necessary, if one has decided to remove this ulcer, to make a typical total segmentary resection of the stomach, as described by Riedel and Payr. After total vertical section of the stomach more or less near the pyloric antrum, one takes away the proximal gastric strip and detaches the posterior adhesions. In case of ulcer penetrating only the pancreas, practically a frequent occurrence, the opening of the stomach is inevitable at this point in the operation. There is left in place the bottom of the ulcer which is formed of the pancreatic tissue. This surface should be cauterized and with careful drainage of this infected zone with its doubtful vitality, one may obtain success. Riedel, Payr and Küttner have demonstrated this and we have had occasion to practise it twice successfully. Acquaintance with the operative technic is important for often operators hesitate to resect such an ulcer from its adherent point. The liberation posteriorly having been completed one may draw out progressively the proximal portion of the stomach and make a total vertical section of it at a point judged convenient. It is necessary in these gastric resections to use great care in the hæmostasis of the cut edges. The stomach in these cases is very vascular, congested and bleeds much more easily than in cancer. It is

better to ligate separately the great trunks which spurt along the gastric edge and it would be imprudent to depend for hæmostasis only upon the general overcast suture which may become relaxed through gastric peristalsis. According to the extent of the resection and the possibility of bringing together the two gastric edges, one may decide then to finish the operation either by end-to-end anastomosis of the two gastric ends, or by separate closure of these two ends followed by gastro-enterostomy upon the cardiac pouch. True, these operations of resection of ulcer, often extensive and complicated by posterior adhesions, are not always simple; but taking into account the gravity of callous ulcers of this region and the frequency of the later development in them of neoplasms, it is of great advantage to practise it. We are persuaded that here the surgery of the future will establish proper indications and technic.

THE DIAGNOSIS OF GASTRIC AND DUODENAL ULCER*

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The extent to which surgical operations in cases of gastric ulcers may be successfully performed depends chiefly upon our ability to diagnose. Progress in the last decade does not lie principally in the field of intense cicatricial contraction, of gastric hemorrhages and of acute perforation, *i.e.*, of those diseases which could readily be recognized as early as two decades ago, but rather in the realm of the extra-pyloric gastric ulcer and ulcers of the duodenum, *i.e.*, cases which, unless accidental bleeding or acute perforation set in, had heretofore been regarded as "gastralgias" and "gastric neuroses" and treated in various baths and nerve sanatoria. In spite of the fact that an occasional ulcer had been surgically treated before the introduction of the Röntgen rays, nevertheless a definite and systematic plan of procedure could only become a genuine possibility after their introduction, substituting, as it did, the benefits of clear vision for uncertain conjectures and theoretical deductions. Progress thus made manifested itself not only by the ever-increasing number of operations for gastric and duodenal ulcers actually performed but also by the great number of published articles appearing in this newly discovered field of activity.

Other benefits derived by X-ray examinations even surpass the advantages naturally obtained through diagnosis made *ante operationem*. The X-rays enable us, in a manner heretofore impossible, to discover the causes of immediate post-operative disturbances and subsequent ill effects thereof; and furthermore to exercise a certain self criticism formerly too often supplied by the internist, which, though sometimes just, was too frequently lacking in any sure foundation.

It may be said in advance, that in the present paper essentially only those methods will be referred to, which are generally available in surgical practice. First, we lay great stress upon the taking of a series of radiograms which fix the most important phases of the process of digestion. Our proceeding is the following:

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Immediately after the patient has taken 400 grammes of a sufficiently liquid carbohydrate-contrast meal (without milk!), photographs are made, one in the upright position, one in the abdominal position, and one in the right lateral presentation. After 2 and 6 hours subsequent photographs in abdominal position, less often in upright position, are taken. Again photographs after 24, 48 hours and so on, until the bowels are empty from contrast substances. These latter sittings are always taken, if after 6 hours there is still a considerable residue in the stomach and, further, if a disease of the bowels is in question.

We are unable to reconcile ourselves to the double meal recommended by Haudek, at least not as a rule. The advantage which it offers, namely, to require the patient to come but once, is in very many instances amply counterbalanced by the disadvantage, that in consequence of the double introduction of contrast substances the further following in the intestinal canal gives no useful results. We prefer to examine first the process of digestion in the whole gastro-intestinal canal through a regularly carried out series, and later on to make a series of control photographs where they appeared desirable as a result of the first series. Frequently the first series itself gives us the desired information. It is certain, that for the purpose of future documentary evidence and control investigation the examination of a single contrast meal is greatly to be preferred to the principle of the double meal, even though the latter should be less difficult for the moment.

The most important questions concerned are the following:

I. What forms of gastric and duodenal ulcer can be positively diagnosed and which are still resistant to our diagnostic resources?

To answer these questions, the different forms of ulcer must be reviewed separately.

A. The Non-stenosed and Non-perforating Gastric Ulcer.—As long as such an ulcer did not manifest itself by hemorrhages or acute perforation, the diagnosis was until recently but a diagnosis of conjecture, and we can safely say, looking at the operative observations and the findings of autopsies, that many gastric ulcers were not diagnosed and some of those diagnosed were not present. Has the Röntgen picture brought about a change in this? At best only with restrictions. Of course, we became acquainted through it with a symptom which is often found in ulcer, *i.e., the localized spasm of the gastric wall at the site of the ulcer.* The pylorospasm known for a long time as the result of an ulcerating process finds its analogue in ulcers situated at any point in the gastric wall. This localized spasm differs from the

sometimes very intense contractions attending peristaltic waves, as a rule, by constricting the stomach only along the greater curvature. The chief reason for that may be that the ulcers are mostly situated at the lesser curvature. But it is remarkable that I never had occasion to see a corresponding contraction from the lesser to the greater curvature. A further diagnostic sign is, that in ulcer, we always find the spasm at the same place, while we find the contraction of the peristaltic waves, even if it should concern more the greater curvature than the lesser, at different places at different examinations.

A further attribute, which these spasms have in common with the other spastic conditions of the stomach, is that the spasm is not a lasting one. If we inspect such a stomach at the operation, when it is mostly empty, it may be that there is no indication of a spasm at all, even though the stomach had appeared in the Röntgen picture to be bipartite. The spasm, on the contrary, appears, if material is introduced into the stomach, be it only air blown into it (Roepke). It can be made more or less to disappear by the use of atropine or papaverine.

There now arise two further questions important for diagnosis:

1. Does such a spasm only occur in *ulcers?* We have to answer this question in the negative. Stable spasms may arise also without ulcers at the base of the cicatrix after operation or as the result of other anatomical anomalies such as cicatricial bands; even, but very seldom, from the pressure of a corset. Immediately after operations they are, as we will see later on, very frequent. On the contrary, they seem to be very rare in the sharply circumscribed form which attends ulcers, always arising at the same place, in stomachs not yet submitted to an operation. The non-ulcerated gastrospasm, lately more accurately described by Holzknecht, seems to involve mostly larger sections of the stomach.

From the existence of narrowly circumscribed spasms arising after each supply of food we can conclude with certainty that there exists an ulcer of corresponding location. The ulcer itself is delineated in the Röntgen picture only if it has clearly eroded a part of the gastric wall beyond the submucosa so that it is about to become a perforating ulcer.

2. Do we find these spastic conditions in *all gastric ulcers?* Here again we must answer, *no*. We have seen very many pronounced gastric ulcers in which the spasm under ordinary conditions of its appearance was wanting or scarcely to be observed. There are certainly here, too, individual "spasmophil" tendencies (Haudek). For instance, in one of our female patients after transverse resection of the stomach on account of an old ulcer complicated with spasm of high degree with well restored gastric function, a very obstinate *cardiospasm* set in.

In what percentage circumscribed spasm occurs in gastric ulcer is entirely beyond our knowledge, for the spasm is for many cases the only objectively traceable sign of an ulcer. If it is wanting, the ulcer lacking other clinical points can simply not be diagnosed.

It follows from the aforesaid that the progress which we have made in the diagnosis of the non-penetrating gastric ulcers from the Röntgen examination, is only a relative one. Even this is a gain in a sphere in which we have to be grateful for every new diagnostically recognizable sign.

Our ability to diagnosticate gastric ulcer will perhaps at some time be furthered in an important degree by examination of stomach with a gastroscope. But its technic is still in the developmental stage, although some have succeeded in actually seeing ulcers. We must add that this method of investigation for gastric ulcer may not be quite without objection in view of the danger of bleeding and perforation. Fortunately, the imperfections of our diagnostic resources in this particular class is not so grave, because gastric ulcer, neither penetrating nor stenosed, as long as it does not cause hemorrhages, does not happen to be the object of surgical interference, but is left for internal treatment.

It will be very rare that, as Petren and Elgin stated not long ago, a non-penetrating, comparatively recent ulcer gives a niche-forming Röntgen picture through the mere projection of its rarefied base.

Special interest attaches to *non-stenosed and non-penetrating ulcer of the pyloric region.* Mediogastric spasms do not materially impair the onward flow of the contents of the stomach, but such impairment is the case in a higher degree with spasms at the pylorus.

The possibility of a pyloric ulcer is to be considered if with the clinical symptoms of ulcer (pain, hyperacidity, hypersecretion) there is a considerable residue of the carbohydrate-contrast meal found present over 6 hours after its ingestion. This 6 hours' residue is, it may be said, of diagnostic value only when the test meal was a pure carbohydrate-contrast meal, and contained no albumen (milk) nor fat, and if during the first 6 hours neither a further meal nor more fluid were introduced into the stomach. A 6 hours' residuum, caused by purely functional disturbances, can be found, it is true, under the following conditions:

a. In purely functional diminished mobility, especially in connection with ptosis. The stomach shows in these cases a diminished peristalsis.

b. In pylorospasm excited by an ulcer remote from the pylorus. Sometimes there is found in penetrating ulcers at the lesser curvature a

considerable retardation in the removal of food from the gastric section situated beyond the ulcer. This delay is explained by some radiologists as due to a reflex pylorospasm, an explanation which is corroborated by our own observations. Nevertheless, it may be remarked that Faulhaber, on the ground of his experience, denies emphatically the retardation in the exit of food as, of course, also the theory of a pylorospasm due to a distant cause. The retardation in the exit of the food from the stomach can, at any rate, be explained in the sense of a pylorospasm, if it is not caused by a mechanical impediment in the region of the ulcer itself (hour-glass contraction of the stomach) and if the pylorus is not so much distorted by the perigastric process of cicatrization, as to produce a mechanical impediment. It is just this latter point to which little attention has been paid in the theory of reflex pylorospasm. We shall return to it in dealing with the results of operations.

c. In the so-called *duodenal motility, i.e.,* the initially accelerated and subsequently abnormally retarded voiding of the stomach, we find a diminished 2 hours' residue and an abnormal 6 hours' residue, whereas in pure pylorospasm the stomach also holds an abnormally large content after 2 hours. The distinction of both conditions is easily made by an investigation after 2 hours.

d. In toxic pylorospasm (morphine, nicotine, etc.) as a part of the phenomenon of the gastrospasm recently described by Holzknecht and Lueger in its radiologic point of view.

e. In hyperacidity without ulcer.

This short review may show how difficult it is to judge of a purely functional 6 hours' residuum and how careful we must be, even omitting entirely the difficulties of the differential diagnosis in cases of the 6 hours' residue caused by an organic stenosis which we will treat in detail in speaking of the organic stenoses. In summing up we can say that an apparent 6 hours' residue with preserved or even increased peristalsis gives an essential indication but no real proof for the existence of a pyloric ulcer. But we have no way of knowing how often, on the contrary, pyloric ulcers exist without pylorospasm which, therefore, escape entirely our Röntgen examination.

B. The Non-stenosed, Penetrating Gastric Ulcer.—This group contains especially those ulcers for which the surgical treatment has become of importance within the last years, namely, the old ulcers of the lesser curvature. To avoid misunderstanding, we will first of all briefly describe the action of the penetrating ulcer:

The penetrating ulcer is one which perforates all layers of the gastric

wall, while the gastric cavity is separated from the abdominal cavity by the substance of the gastrohepatic ligament or by adhesions. For the formation of this ulcer three possibilities are to be considered:

1. The ulcer is situated exactly at the lesser curvature (very seldom at the greater) and gradually corrodes through all layers to the point of attachment of the gastrohepatic ligament. This ligament forms the natural protection against perforation into the abdominal cavity. Through proliferation and thickening of its connective tissue it makes the base of the ulcer continually more compact without the necessary addition of other adhesions.

2. The ulcer comes to the surface at another place. As in every subacute inflammatory process which goes on in the intestinal canal from inside to outside, the serous membrane reacts with the formation of fibrin. Thus arises a circumscribed perigastritis. A real perforation need by no means occur. The formation of fibrin leads to agglutination with adjacent organs, especially with the posterior abdominal wall in the neighborhood of the pancreas, and anteriorly with the liver. When the process is comparatively acute, the omentum greatly assists in thickening the endangered spot and protecting the rest of the abdominal cavity. Into the adhesions thus formed the ulcer burrows deeper and deeper, and at the same time the adhesions extend further and further.

3. There may be formed an acute and greatly circumscribed perforation, sometimes not larger than a pinhead. When this appears in a not overfilled stomach, and the quantity of the escaping liquid is not large, it reacts in the manner described under 2, with formation of fibrin, with the aid of the neighboring serous surfaces and the omentum; the further course is, with or without the formation of an abscess, that already described by us under 2. The size of the abscess is of no concern; for extensive epigastric abscesses can heal up whether by simple resorption or by self-drainage into the stomach as long as the base of the ulcer is adherent to a neighboring organ or, more exactly, formed out of it. The question of the extent to which adhesions may develop will be discussed later. We know especially from appendicitis, to what degree an abdominal cavity entirely obliterated through inflammatory processes may in time be restored.

Our observations made years ago upon the varying extension of the peritoneal processes in encapsuled perforation, led us to conclude that without doubt a part of the so-called penetrating ulcers pursue this course. We must not, however, overlook the significance of the other modes of origin.

Form 2 is really the mildest of all forms of the protected perforation.

In this occurs first diapedesis of micro-organisms and then the formation of fibrin upon the serous membrane. Only after the development of adhesions occurs the perfect destruction of the gastric wall at the base of the ulcer. These processes can be observed very distinctly in the different phases of the dilatation ulcers of the colon. We need hardly mention that we have abundant opportunities to see aggregation of fibrin and agglutination about ulcers of the vermiform appendix which are not yet perforated.

For a better understanding we may classify questions of diagnosis as follows:

1. *Ulcers at the lesser curvature and its adjoining region.* Prior to the time of the Röntgen rays, we were able at best only to guess the existence of ulcers, as long as there was no bleeding. Now the diagnosis, when the technic of the examination is a proper one, should be quite certain. Its particular feature is the *notch* which was first recognized by Haudek in its full importance. Their characteristic signs are: (*a*) the sharply circumscribed protrusion at some point in the lesser curvature; (*b*) the gas bubble frequently found above the contrast shadow in the erect position; (*c*) occasionally, the remaining for a longer period of the contrast substance in the notch after evacuation of the stomach.

Although it may be a simple matter to discover the notch in typical cases, nevertheless we must beware of false conclusions. It may easily be overlooked. This is particularly so when the ulcer is situated very near the cardia. Then the gastric filling does not extend high enough, especially not when the examination is made in the erect position, possibly not even in the horizontal position. Provided there is sufficient evidence of an ulcer, the patient must be examined in an oblique position with the upper part of the trunk lying low (Trendelenburg's position) and finally in the right lateral position. Besides this we must also give in such cases a larger quantity of contrast pap than ordinarily, for instance, 600 instead of 400 grammes.

In other cases the symptom may be recognized only indistinctly in consequence of chance insufficient filling of the notch, even if it lies lower down. A new examination, also in right lateral position, with very watery contrast food, often shows it very distinctly.

Sometimes, on the other hand, shadows which have nothing to do with the notch are taken for such. I will not speak of the transverse spinal process shadow, calcified glands and renal calculi which the beginner occasionally confuses with a notch. Doubts arise rather from accidental gastric pouches caused by certain states of contraction, especially by the bulging between two waves of contraction following close

upon one another. A marked picture of a notch with a covered-over bubble of gas may be mistaken for the duodenal ampulla or stomach cap. If doubt persists, repeated examination, after atropine injection, must be made.

A symptom which greatly facilitates the diagnosis of the notch is the existence of a permanent contraction at the greater curvature at a point corresponding to the notch in question, or even the picture of a cicatrized hour-glass stomach. But it may be said again that we do not always find a spastic constriction of the greater curvature in every case of penetrating ulcer of the lesser curvature.

The striking frequency of ulcers at the lesser curvature in the Röntgen picture suggests the further question, whether all notches appearing in the Röntgen picture at the lesser curvature are really situated there. This question can be easily answered in the negative. Because of the fact, that an ulcer in the neighborhood of the lesser curvature, whether situated on the anterior or posterior surface of the stomach, fastens itself to the posterior abdominal wall, the liver, etc.; it becomes, so to say, the fixation point for the stomach and thus replaces the support which the stomach normally has at the gastrohepatic ligament. In consequence of this the latter will be somewhat stretched, and the stomach, influenced by gravity, topples over, according to the location of the ulcer, either toward the front or the back, so that the lesser curvature lies a little to the front or to the back, and the ulcer takes its place. Many ulcers seated apparently at the lesser curvature are in fact merely in that vicinity.

Views of the stomach without contrast meal, with air or gas inflation alone, sometimes give pictures very characteristic of ulcers through the dark band and the hour-glass contraction, but they are not to be generally resorted to, because they cannot replace the contrast view, and because we have to limit ourselves, to save time and expenses, to those views which give us a maximum of information. Besides, the danger of perforation through gas inflation is not inconsiderable.

2. *Ulcers remote from the lesser curvature.* When a penetrating ulcer is so far distant from the lesser curvature that it cannot reach the right boundary line of the stomach shadow, *i.e.*, the place of the lesser curvature when the stomach is toppled over (rotation around its longitudinal axis), it is not demonstrable through the Röntgen picture in the anteroposterior view. But such an ulcer could be shown if, after evacuation of the stomach, a shadow of contrast substance should appear at a circumscribed unchangeable place. This is especially true of the ulcers of the posterior gastric wall. Ulcers of the anterior wall which

are so far away from the lesser curvature that they do not lie within its region are not yet described as taken into the Röntgen photography. They may be so rare that this kind of diagnosis with its difficulties has no practical value. For such ulcers of the anterior and posterior wall remote from the lesser curvature, the profile view of the stomach, proposed by Cole and lately by E. Schlesinger, ought finally to be considered, a matter heretofore too much neglected.

C. The Stenosing Gastric Ulcer.—Stenosis, as well as a hemorrhage, the results of an ulcer, could be diagnosed without difficulty even prior to the Röntgen period, provided the clinical symptoms of retention were present. But in this case too the Röntgen examination has been an aid, whereas formerly the existence of a stenosis was disclosed by the patient having seizures of marked board-like contraction of the stomach wall, or signs of severe dilatation or even retention vomitus, and when the stomach tube showed food residues of the previous day. We are now able by means of the Röntgen examination to perceive stenoses of a lighter grade without repeated use of the tube, and to determine its exact location. Whereas formerly the majority of the mediogastric stenoses were clinically considered as pyloric stenoses, and only the experienced observers were correct in their diagnosis of "hour-glass stomach," to-day we can recognize both principal forms of ulcerative contraction of stomach by a mere glance at the Röntgen picture. We distinguish:

1. *Mediogastric stenosis* (*hour-glass stomach*). Every one knows that in the beginning of the study of X-rays of the stomach wrong use was made at times of the expression "hour-glass stomach." This term was used for every bipartition of the Röntgen shadow, until it was recognized that the greater part of these bipartitions do not depend upon an anatomical change, but only upon a circumscribed spasm. Extensive experience, however, permits us to set up the following types of bipartition of the gastric shadow:

(*a*) *The purely spastic hour-glass stomach:* This has previously been found in connection with the superficial gastric ulcer, and likewise appears again with the penetrating ulcer.

(*b*) *The mixed hour-glass stomach:* Combination of cicatricial contraction of the stomach with spastic constriction. In these cases the cicatricial contraction is not so pronounced as to substantially interfere with the permeability of the stomach. If such a case should appear, however, it would be caused by the spastic component. In the Röntgen picture this form very much resembles the purely spastic hour-glass stomach,

and a sure differentiation cannot be made with the Röntgen picture, if the atropine test remains uncertain.

(*c*) *The cicatricial hour-glass stomach* which alone deserves its name in the old sense. Here, through further and further contraction of the gastric wall in the region of the ulcer, the lumen is finally narrowed to a minimum. The highest forms of the stenosis differ from the spastic hour-glass stomach by the fact that the flow of the contrast pap into the lower gastric section is very much retarded, whereas in the truly spastic hour-glass stomach both gastric sections fill up, one right after the other, and in consequence are filled just after the ingestion of the contrast meal. Moreover, where this symptom is not evident, the cicatricial hour-glass stomach differs from the spastic, mostly by the more funnel-shaped constriction, arising not only from the side of the greater curvature, but at times also by the peculiarities and irregularities in its form. Finally, a cicatricial hour-glass stomach cannot be influenced by atropine.

In comparing the clinical symptoms with the results of the Röntgen examination we find that real phenomena of obstruction of the stomach contents are not met with in spastic and mixed hour-glass constriction, but only in the purely cicatricial type. When we are able to take out by siphon method food residues of the previous day, or when we find a remainder of 12 to 24 hours in the upper sac, then the hour-glass stomach is an anatomical one, even if the first Röntgen picture should, by exception, leave us in doubt.

Tuberculous changes (Fischer) and luetic gastric ulcers (Holissch) may exceptionally lead to the hour-glass type. But these occurrences are so rare that they cannot be regarded as typical results. Anamnesis, clinical and serological symptoms will give essential indications, operation alone, however, will reveal the correct facts. Later on we will speak of the carcinomatous hour-glass stomach.

2. *Ulcer at the pylorus with stenosis.* With the pyloric ulcer the problem is to recognize the stenosis as an anatomical one, not caused by pylorospasm only, and later, if possible, to differentiate the different forms of anatomical stenosis.

The occurrence of the following symptoms tends to prove the case to be one of *organic stenosis:*

(*a*) The clinical symptoms. Special prominence of pain, irregularity of the attacks, short duration of the signs of retention are characteristic of spasm; but retention existing for a longer time, gradually increasing with uniform troubles, indicates organic narrowing. The latter also shows fluctuations just in accordance with the state of com-

pensation of the muscular apparatus of the stomach, but these fluctuations are not the sudden, incalculable ones such as attend pylorospasm, and above all depend less upon the nature of the food that has been introduced.

(*b*) The time relations of the retention. One might emphasize here that the Röntgen picture alone does not provide in all cases a clear image of the proportions of retention, and that, as Hürter claims, the result of the clinical locomotion tests ought to be taken into account. One fact especially is to be emphasized: The contrast pap, whether in normal time or whether somewhat delayed, can be entirely expelled even where larger food particles are retained through mechanical impediment. This is true of the common gastric ulcer, but especially so of the carcinoma, in which case the contrast meal often enters the intestine at the normal rate of time; while coarser food particles, for instance residues of prunes, are retained 12 and more hours. In one instance of carcinomatous stenosis I observed that more than twelve half figs had been remaining in the stomach for two weeks, while the entire contrast meal entered the intestine, though somewhat retarded. In cases of ptosis larger food particles are said to remain in the bottom of the flabby gastric sac (Sahli). By bearing these facts in mind and not neglecting the ordinary motility test we are able to obtain through the Röntgen picture both valuable and, at times, conclusive indications, and be certain of their accuracy.

In order to diagnose a mechanical stenosis we must know at what moment the evacuation of the stomach may be prevented by purely functional spastic states. To begin with the negative fact must not be overlooked that the evacuation of the contrast meal within 6 hours by no means excludes an organic stenosis. The only sign pointing toward a constriction in such cases is the character of the peristaltic movements, when accentuated in a certain time, but especially when deepened. As we know, a peristaltic wave normally passes over the stomach every 18 to 21 seconds. Thus on one picture at a 5-seconds rate of exposure only one wave can be normally observed. But we have often convinced ourselves that even with a normally functionating stomach 2, 3 or exceptionally 4 light peristaltic waves can be found on the same picture. Anything exceeding that must make one suspicious of stenosis in some form or of an unregulated activity of the stomach in consequence of an affection of the nervous system (locomotor ataxia). That which proves an impediment and causes one to suspect an *organic* stenosis is the accumulation of waves of great depth.

Opposed to the negative fact just mentioned, we are able, in accord-

ance with most of the observers, to regard the following as a positive indication: namely, that if half of the contrast meal remains after 6 hours, this proves with certainty a functional or organic inpediment, without giving more weight to either side. Only a 6 hours' residue, corresponding nearly to the entire contrast meal, which would point toward a probable 24 hours' time of expulsion, is to be regarded with nearly entire safety as an organic stenosis.

(*c*) The action of atropine or papaverine on the spasm. Both drugs are said to relieve spasms and actually do so in many cases, so that the diagnosis can often be established by their use. But some observers, for instance Holzknecht, consider this method not beyond reproach, and consequently it is better to be on the lookout for more essential facts.

(*d*) The water test. As Von Mering first showed, water will pass the pylorus under conditions in which all solid food is held back by a pyloric reflex. Holzknecht and Fujiami, following Schwarz and Kaestle, have, therefore, investigated with the aid of partially submerged, partially floating bismuth pills, both in normal circumstances and in existing pylorospasm, the time consumed in expelling 200 grammes of water from the stomach. The average was about 60 minutes, with a fluctuation of 55 to 80 minutes. In cases of organic stenosis, on the contrary, periods of 105 to 115 minutes were found. Should these findings be further confirmed, we would have in the retarded passage of water a reliable test to differentiate an organic stenosis from a functional one.

(*e*) The shape of the stomach. The shape of the stomach remains, on the whole, normal in cases of purely functional stenoses. An increase in the width of the stomach may, however, be observed in cases of organic pyloric stenosis, so that in the upright patient test residue has a more or less plate-like form, and the pylorus is abnormally dislodged far to the right. A side view shows in cases of beginning stenoses the body of the stomach expanded into the form of a flat cup (Jaubert de Beaujeu), whereas it is usually perceived as a wide diagonal band. The shape of the stomach in chronic dilatation in consequence of organic stenosis in the different positions of the body is mostly so marked, that the experienced investigator establishes the diagnosis at once.

As soon as the diagnosis of an organic stenosis is established, it is worth while to keep separate the two subsequent phenomena of the pyloric ulcer.

Narrowing through rigid inflammatory infiltration of the wall on the one side, and cicatricial stenosis of a healed ulcer on the other are to be distinguished in the following way: Clinically, we sometimes find in the first condition an ulcer tumor, but not in the latter. Furthermore, the first

state appears more acute, *i.e.,* in the course of a few weeks or months, while the cicatrix has been long accumulating and is usually the final result of a patient's history dating back several decades. If the unusual finding of a notch picture in the pyloric region does not make a diagnosis possible,—we have never seen it,—we cannot draw any certain conclusions from the Röntgen picture. The following consideration allows, at any rate, a relative inference: The stenosis caused by infiltration of the wall suppresses a proportionally broad section of the pyloric shadow and of the adjacent zone of the pars pylorica, the cicatrix formed, like a diaphragm, suppresses only a small zone. Where the stenosis is not a perfect one, and we can see, under certain circumstances, the bulbus duodeni filled, we will regard a broad zone of suppression between duodenum and gastric shadow as due to a callosity in the wall, and regard a narrow zone of suppression as a pure cicatricial stenosis. Larger hemorrhages are also indicative of an actual ulcer. The suppression of a part of the pars pylorica in the gastric picture is, however, so suspicious of cancer that it will be seldom possible to exclude carcinoma with any probability by means of the Röntgen picture alone. We can be certain the case is cancer, when with such a gastric picture the evacuation is a normal or even an accelerated one. The picture of the cicatricial occlusion of the pylorus may be confounded with that of the shrinking pyloric carcinoma.

D. The Non-stenosed Duodenal Ulcer.—A duodenal ulcer is one lying chiefly beyond the pylorus—at most its outer edge may be contiguous with the pylorus; a *pyloric ulcer,* on the other hand, particularly when it is deep rooted, infringes upon the mucous membrane of the pylorus, and even upon the sphincter itself. As far as the functional disturbances themselves are concerned, it is a matter for the individual to decide, whether an ulcer be duodenal or pyloric in its nature. But the designation ought to be such as to present the facts in a purely objective manner. Unequivocal, positive signs of duodenal ulcer are to be had neither in the anamnesis, in the clinical findings, nor in the Röntgen picture. If we accept the symptom, so masterly described by Moynihan, the symptom of the periodical secondary pain after taking of food, often retarded several years, as suggestive of a duodenal ulcer, we must try to establish the positive diagnosis by testing accurately the gastric contents and the fæces for blood, since pains of an entirely similar nature are observed without any formation of ulcers. If positive traces of blood are found in both the gastric and intestinal contents, this would be indicative of a gastric ulcer; but when the traces of blood are found only in the intestines, this would indicate an ulcer of the duodenum. Every precau-

tion must, of course, have been employed to guard against the admixture of blood traces from any other source or from any other cause.

Important as is the presence of blood, it is, nevertheless, not decisive; for, as many observers remark, blood is often absent in actual ulcers or is only present intermittently. When no blood is found after repeated examinations, we must seek for another indication of ulcer in the sensitiveness to pressure in the region immediately at the right of the median line.

The first to which we pay attention is the mode of evacuation of the stomach. Moynihan, Barclay, Hertz, Meunier, Holzknecht, Haudek, Kreuzfuchs and others have stated the following as the *type of the gastric evacuation* in duodenal ulcer: At first the stomach empties quicker than normally, so that after 2 to 3 hours the whole or, at least, the largest part of its contents is found in the intestine and descends then comparatively quickly. Toward the end the emptying often retards, so that, on the other hand, contrary to the normal process, a 6 hours' residue often remains. Despite this 6 hours' residue, the contrast filling in the colon is said to have pushed forward abnormally far, as far as the plexura linealis, according to Jonas. The abnormally quick emptying is explained in the sense of a reflex insufficiency of the pylorus, and, in fact, we find in the Röntgen picture and on the screen the pylorus abnormally open. The 6 hours' residuum, by no means regular, is referred by Kreuzfuchs to a retarded pylorospasm. We cannot here enter upon the details of the various theories that have been advanced with reference to this peculiar disturbance of the intestinal motility. Further observations have shown, on the one hand, that this duodenal motility is by no means found in all cases of duodenal ulcer and, on the other hand, that it is observed in other very different affections of the duodenal region. Thus it is found according to Bergmann in hyperacidity without ulcer. Again, we find it in the early stage of carcinoma of the body of the stomach. Finally, it is seen just in those diseases which compete with the duodenal ulcer in differential diagnosis, namely, in diseases of the pancreas and the gall-bladder. The duodenal motility is, therefore, but a sign awakening suspicion, not a pathognomonic symptom.

To recognize it, we must either observe the patient during a longer time at the screen at the beginning of the emptying of the stomach or, what is more simple and sufficient for practice, make an X-ray examination 2 hours afterwards, as is always done in a case where a duodenal disease is suspected. If, after that time, the most of the stomach contents, perhaps even the entire contents, are in the intestine, we may regard this as an accelerated evacuation.

Interesting as a rare isolated observation, but for the present without demonstrable internal connection, is the appearance of *spastic hour-glass stomach* with duodenal ulcer. Inasmuch as control by an autopsy is not available, the existence of a small superficial ulcer of the stomach cannot be excluded, because it can easily be overlooked during the operation, especially as its presence need not appear at the outer surface of the stomach. Therefore this symptom has as yet no diagnostic value.

A peculiarity, if functional, brought on by the evacuation of the stomach, if organic, by the bending of the duodenum, is the existence of a shadow in the bulbus duodeni, the stomach cap, as it is very significantly called by Cole. This latter is regarded as in some degree characteristic for duodenal ulcer. But its presence is so frequent an occurrence that I would not lay the least stress upon it, unless it shows a nicely round form or one that is running to a point like a hood. It is another thing if it shows itself in the same way distorted at different views. Then we would have the right to presume if not a duodenal ulcer, at least inflammatory adhesions of some kind in the duodenal region. They could be due just as well to an old cholecystitis as to an inflammatory process in the duodenum itself. As a control in the differential diagnosis of such adhesions the examination in the right lateral position, as already mentioned, is to be recommended.

The persisting duodenal shadow is of far greater significance. The remaining of contrast substance in the duodenum at a circumscribed place, after complete evacuation of the stomach and the upper small intestine, has from the beginning been considered as a sign suspicious of a duodenal ulcer. In fact, it may be a case of contrast substance remaining in a notch situated behind the duodenum. Likewise it could be regarded as one of those congenital diverticula described by Wilkie and others; and finally, as I myself have observed, such duodenal spots are also found at pouch formations through adhesions between the duodenum and neighboring organs, the liver or the gall-bladder. But these adhesions are not necessarily connected with a duodenal ulcer, yet may be caused by a cholecystitis. Thus the persisting duodenal shadow is important as awakening suspicion, but is by no means a certain sign, that an ulcer still exists.

More proof of the existence of an ulcer is given by the notch, *i.e.*, a shadowy prominence projected beyond the duodenal shadow, if positively demonstrated by repeated observations. But this notch is so extremely rare at the duodenum, that it has, as Haudek admits himself, no great practical value for the diagnosis. Besides mistakes are here more easily possible than with notches of the stomach, and Haudek

himself emphasizes that above the bulbus shadow there is often a gas bubble which may give rise to an erroneous conception that this is due to a notch. He adds that he never observed a gas bubble at the notch spot of a penetrating duodenal ulcer.

Furthermore it is to be noted, that the duodenum, with respect to the entire pyloric region, can be shifted very little. This sign, too, is but a relative one, since the diminution of the facility with which the duodenum may be shifted, may originate as well in an extraduodenal inflammatory process or in a malignant neoplasm, as in a duodenal ulcer. At any rate its proof is of importance in so far as it shows us, at least, that in the duodenal region an inflammatory process is still existing or terminated. The demonstration of this fixation is still deficient, as we will see in a special chapter.

All the points have now been considered which may be utilized for purposes of diagnosis in the case of duodenal ulcer. The conditions of the stomach secretions should, for the sake of completeness, be examined in each case; but we cannot draw any diagnostic conclusions from the findings, because, as all observers agree, in regard to the reaction of hydrochloric acid as well as to the motility, the most marked changes may be produced by a slight sickness, and even so irregularly, that the predominance of the anomaly or the other—increase or decrease of the free hydrochloric acid—seems to be a matter of chance.

Whether the experiments of Einhorn in obtaining a blood spot from the duodenum by the thread test, or to procure some of its contents by aspiration through a tube or finally to obtain a full destruction of it with contrast substance by means of a duodenal obturator, will aid in the diagnosis of the duodenal ulcer, only time will tell. Positive proofs are, as far as I know, still lacking.

With reference to the diagnosis of duodenal ulcer and especially the significance of examination by the Röntgen rays, the following summarizes the situation:

When the anamnesis and the clinical conditions indicate the probability of an ulcer or prove it directly by hemorrhages, we conclude by the negative findings in the stomach, that the ulcer is very likely situated in the duodenum. Diagnosis of a gastric ulcer is usually a positive one, that of the duodenal ulcer a diagnosis *per exclusionem.* It consists on the positive side of a number of symptoms, some of which are of themselves proof, and which are important only because of their relation to one another.

E. The Stenosed Duodenal Ulcer.—We can readily separate the stenosed from the non-stenosed ulcers in diagnostics, because we are

now on secure ground. The chyme normally passes the duodenum so quickly and in such small quantities that we never get in the Röntgen picture a complete filling out or even a somewhat complete outline of this part of the intestine. If we find it densely filled with contrast substance so that we can clearly follow its course in its entire extent or, at least, to a certain point, we must conclude that there is an obstruction further down. Concerning the nature of this obstruction the Röntgen picture is of no avail. I have known such duodenal filling to be caused by the compression of tuberculous glands and by pericholecystic inflammatory processes. We may regard the stenosis as an ulcer only when another cause is lacking, and when the anamnesis itself indicates duodenal ulcer. These restrictions are necessary, also because stenosis is a very rare occurrence with duodenal ulcer. Under certain circumstances we will recognize, as Bier describes it, the cone-shaped filling of the constricted lumen in the Röntgen picture. The significance of fruitless peristaltic waves above the stenosis is referred to by Holzknecht. It is remarkable that it needs a considerable constriction in order to bring out such demonstration of filling of the duodenal section above the stenosis, and that the stomach shows very late decided symptoms of regurgitation. The dilution of the contrast meal, already mixed with gastric juice, by bile and pancreatic juice, explains this sufficiently.

It may be mentioned in passing, that theoretically the filling out of the duodenum with contrast substance must also arise in cases of arteriomesenteric intestinal occlusion, particularly when there is a decided bend of the duodenum as it becomes jejunum. But the fact that in reality such a stasis is rarely observed, shows, as Moynihan correctly remarks, that Lane and Jordan go a great deal too far in their diagnosis, and that their conception is not justified by the Röntgen picture.

II. How can adhesions be recognized?

Closely connected with diagnostics of ulcers are those of adhesions. The clinical examination of these leaves us entirely at sea, and if we establish the diagnosis of " adhesions " on the ground of clinical symptoms exhibited by the stomach—as well as anywhere else in the abdominal cavity,—we must always be aware that we are expressing a mere guess.

Abnormal adhesions involving the stomach can be anticipated from the following three conditions:

1. An abnormal position of the pylorus, the stomach being but normally filled.

2. The too slight displacement of the pylorus upon examination in different positions of the body.

3. From anomalies of the stomach not otherwise explained.

1. *Abnormal position of the pylorus* means either unusually remote distance from the median line to the right (right distance) or, on the contrary, a situation on the left side of the vertebral column or an abnormally low position. The normal pylorus is normally situated about on the line of the right transverse vertebral processes. A decided dislocation to the right suggests adhesions only when it is not caused by an abnormal state of fulness of the stomach (retention) or by temporary rigid contraction of its wall (gastrospasm). Also when it can be taken as the result of an adhesion provided the pylorus does not descend when the patient's position is changed.

Usually the pylorus moves somewhat toward the median line when the stomach is emptied. Its situation left of the median line is in all probability caused by adhesions. This certainly does not point toward ulcerative adhesions, but, as experience shows, toward carcinomatous fixation.

From abnormal descent itself we can conclude *a priori* only upon increased motility. Fixed descent is very rare. For the sake of completeness it may be mentioned, that the whole stomach may be displaced in any direction in the widest sense by large abdominal tumors. The form of displacement of the stomach is usually in a sickle-shaped (falciform) or ligament-like distortion of such a nature that no doubt may rise.

2. *To test the displacement* of the pylorus we compare the pictures of the examinations in upright and horizontal positions. Normally we find a movability of the pylorus to the extent of 2 to 3 vertebræ (7 to 10 cm.). Fixation through adhesion may be supposed when the displacement, upon the change of position with the same gastric content, is a good deal less than this. Most reliable will be the diagnosis of pyloric adhesion, if we can prove both abnormal situation and faulty displacement. Even then we do not know whether the interference with the displacement is not due to a disease of neighboring organs (gall-bladder and pancreas). The inspection of the Röntgen pictures shows, in conformity with the findings at operations, that the displacement of the pylorus itself, while the ulcerative processes are active, depends very essentially upon that of the entire abdominal viscera.

3. One is inclined to infer the presence of adhesions from gastric and duodenal change of form, otherwise inexplicable. This conclusion is justified in the cicatricial hour-glass stomach, with which there is always

an abnormal fixation at least to the gastrohepatic ligament and generally at each pronounced notch. Also in the region of hour-glass stenoses and notches we often find in the stomach picture either protrusions running to a point or, on the other hand, constrictions which distinguish themselves at the first sight from the more roundish constrictions or protrusions of the peristaltic waves, the constancy of which at different takings permits the certain diagnosis of constricting adhesions. At the greater curvature such adhesions are rarer, but irregularities in the marginal outline in consequence of the contiguity of the transverse and descending colon are very frequent. To infer adhesions from irregular form of the greater curvature is only permitted, when the change of form persists at each taking, even after evacuation of the colon, and when it cannot be explained by displacing tumors situated without the stomach. Finally, it must be recalled that sometimes very marked cicatricial bands cause no changes of form of the stomach.

Of special importance is the diagnosis of adhesions in the region of the duodenum. By their presence, as we have already seen, the duodenal spot is sometimes to be explained, which remains after entire evacuation. By adhesion the duodenal wall is drawn out like a pouch and in this the contrast substance remains for some time. But this pouch formed by adhesion cannot be distinguished from a congenital pouch or an ulcerative notch. With greater certainty we can establish the diagnosis of adhesion, if the filling of the bulbus duodeni, the so-called gastric cap, shows an irregular form. Most frequently it presents itself normally as a pointed cap with nicely caudate edges, less frequently as a roundish formation with smooth edges. But if we find the same anomaly of form at the same place after several sittings, we may decide for adhesions with some probability.

The more carefully we control the diagnosis at the operation, the more we receive the impression that even now *in X-ray work,* as formerly was the case *in clinical observation,* adhesions are diagnosed too often.

III. How can we recognize or exclude the carcinomatous degeneration of a gastric ulcer?

It is not in the intent of this report to consider the differential diagnosis between gastric ulcer and carcinoma to its full extent. Consequently we limit ourselves to the question, whether and how far the Röntgen picture permits us to recognize, in the presence of symptoms of ulcer, whether or not the disease had already changed into carcinoma. The answer to this question has less importance than the further ques-

tion, not *whether,* but *how* it is to be operated, and what will be the prognosis of the interference.

It may appear simpler, since an operation must be done at any rate, to leave the decision of the question, whether it is a simple ulcer or carcinoma, to the operator. But the experienced surgeon knows, that the examination of the open abdomen does not always permit a decision, and that he is frequently happy to possess, also, clinical findings accurately taken and a good Röntgen picture as a foundation of his diagnosis and his therapeutic decision.

It may be permitted, without going into detail of the problem, to insert some observations concerning the *subsequent carcinomatous degeneration of the simple ulcer.* If we are to discuss the radiological signs of such a degeneration, we must first know whether it exists at all. This carcinomatous degeneration of an originally simple gastric ulcer, affirmed without any trace of proof in various even pathologico-anatomical researches, is emphatically denied by Duplant on the ground of careful investigations in a study much too little known. Between these two extremes there are those newer studies which try to assign a certain percentage between benign callous and cancerous gastric ulcer, especially on the ground of clinical material gained through operation for the pathologico-anatomical investigation. Such examinations are of no small importance for establishing an indication at the open abdomen. The numbers gained by this method are so contradictory that they can be utilized only with great care.

To know the frequency with which a simple ulcer becomes a carcinoma in its further development, we must renounce, because we will never know, how many gastric and duodenal ulcers remain clinically latent and are not even found at autopsies. Just as little will we be able to ascertain, how many carcinomata originated from an ulcer, since the ulcer may have remained latent in a single case, and since the carcinoma is often so far developed at the time when it causes clinical symptoms, that its origin *ex ulcere* is entirely effaced by the carcinomatous destruction of the tissues. Finally, primary carcinomata may afterward assume, by ulcerative disintegration, as Duplant says, certain features of a primary ulcer or at least of what we call a *"carcinoma ex ulcere."* We will be able to establish only, how many cases showing the appearances of a pure ulcer in their history and clinical symptoms, and also presenting the signs of a simple callous ulcer at operation, have proved themselves to be carcinomata by their further development and the histological investigation, and on the other hand, how many of the carcinomata examined histologically point toward an original ulcer through

their anamnesis and through their pathologico-anatomical signs, for instance, the course of the muscularis.

That a carcinoma may develop from a simple ulcer, be it callous or not, is made probable through the general experiences of the pathology of tumors. That this change really occurs, is positively proved by clinical observation and histological examination. But we cannot make any certain conception as to the frequency of this occurrence. The most reliable data must be obtained from the further observation of patients subjected to gastro-enterostomy, because here the diagnosis of ulcer was not only clinically established, but also confirmed through the findings of the operation. If we take into consideration that here the development of carcinoma is observed only in 2 per cent. of all cases from a very large series of figures, we may at least conclude that the carcinomatous degeneration of a round gastric ulcer is of relatively rare occurrence. The possibility that the gastro-enterostomy has operated against the development of carcinoma, could have been adjusted statistically by the fact, that, on the other hand, among the cases considered as simple ulcers at operation there could be primary carcinomata histologically found at the time of operation, and that not all gastric carcinomata originated *after* a simple ulcer did so *because* of it.

It is important, as soon as there is suspicion of cancer, to search for metastases. Strauss, in view of the difficulty of the differential diagnosis which we are occupied with, refers to the importance of the metastases in Douglas' pouch demonstrable from the rectum, which he found in about one-tenth of all cases of his patients with gastric carcinoma. Schnitzler, Bensaude, and Boas also call attention to the diagnostic and prognostic importance of these metastases.

The chief progress of the last years in the differential diagnosis between simple and carcinomatous ulcer lies in the *Röntgen examination.* But even this, indeed, does not always give the desired decision, and we must too frequently leave the question open even after having taken the Röntgen picture into consideration.

To begin with the *ulcer of the central part of the stomach.* The characteristic feature of the penetrating ulcer is the notch, thus causing a plus of shadow; the characteristic of the carcinoma is the erosion, thus causing a minus of shadow. But, indeed, it happens that the central crater of a carcinoma, decayed through ulcerous degeneration, presents itself as a notch, and *vice versa* that of an ulcer penetrating a notch in carcinomatous degeneration of secondary masses of a tumor which protrude into the stomach and which have undergone erosion. In either case we may believe that a pure notch is presented to us. But

if we imagine the boundary line of the lesser curvature continued on both sides to the region of the notch, we may ascertain in general, whether along with the formation of a notch there also exists a real erosion of a proliferated mass of tumors into the gastric lumen. Especially is the decision easy when the erosion in the gastric shadow around the notch appears irregularly bounded or knobby or like digital impressions. But there are cases with which belong the observations communicated by Holitsch which have a doubtful interpretation. In a single case it may be very doubtful, how to imagine the contour lines of the lesser curvature continued beyond the notch.

More difficult still is the judgment of *stenoses of the pylorus*. Typical for pure ulcerative stenosis is smooth closure of the shadow at the pylorus joined to an unusual situation of the pylorus to the right, in consequence of the dilatation of the stomach,—the latter dependent upon the longer period of development of the stenoses of the ulcers. Where this smooth closure is present with nicely caudate marginal outline and where the stomach contents do not extend cone-shaped into the strictured region, there we can justly suppose a benign ulcerative cicatrix, and there it is entirely impossible, relying alone on the Röntgen picture, to differentiate the ulcerative stenosis from certain small, shrinking, slowly growing carcinomata. More often we find with the pyloric carcinoma a somewhat irregular boundary of the gastric shadow, the enclosing of a piece of the antrum pylori into the stenosis, marked left situation of the whole stomach as contrasted with the pronounced right situation, nearly regular, of the ulcerative stenosis, small displacement of the pylorus in changing the position (according to our observations on the average over the space of but one vertebra), so that in the majority of cases the experienced observer is not in doubt. Whether the carcinoma is a primary one or a secondary implantation upon a pyloric ulcer, does not play any rôle for the differential diagnosis between ulcer and carcinoma.

Essentially more difficult is the Röntgen diagnosis of the duodenal carcinoma, whether it be growing upon an ulcer or not—a question which shall probably always be an open one. The cases of duodenal carcinoma which I have observed within the last years, could not be positively diagnosed with the aid of the Röntgen picture. Ordinarily we obtain merely indirect signs which point toward this diagnosis, especially those of occlusion of the ductus choledochus and of the duct of Wirsung. We will always think of carcinoma, if we find an abnormal duodenal filling with irregular boundary in the Röntgen picture, the clinical signs of which do not date very far back.

IV. What conclusions may be derived from the examination technic of the present day as to the indication for operation and to the choice of the method of operation?

1. If manifest or occult hemorrhages are lacking, the Röntgen picture is entirely normal, and there are but subjective complaints, *i.e.*, pains, the degree and the character of the latter will determine our decision. If the pain takes the character of that connected with an ulcer, it will essentially depend upon its intensity and the disturbance of nutrition and vocation caused by the former, and also upon the success of internal therapy, whether or not we propose operation to the patient. It will be first of all an explorative one. But from the beginning we will, above all, focus attention upon the duodenum, because experience shows that with complaints of ulcer of longer duration and higher degree, while the gastric picture is nevertheless normal, the ulcer is very seldom situated in the stomach.

2. If the Röntgen findings are negative, if there is no clinical retention, but if the diagnosis of "ulcer" results from manifest or occult hemorrhages, the indication for operation after the failure of internal therapy is a more decided one. Here, too, the lack of changes in the gastric image points to the duodenum. What the method of operation in such cases shall be,—only gastro-enterostomy or closure of the pylorus in any form,—the examination cannot decide; that depends only and solely upon the conception and experience of the operating surgeon and the general condition of the patient.

3. If we find in the Röntgen picture the signs of retention followed by pyloric stenosis, operation is indicated. The larger the residue in the stomach is and the longer it remains there, the more urgent the operation. Thus, as we have already seen, a small residue after 6 hours proves nothing. In case of a large residue after 6 hours but which evacuates within the first 12 hours, the indication is not very urgent. But it is so if there is a residue after 24 hours, although there are patients who are able by special skill in feeding to keep themselves at a fair equilibrium for a long time with such a stenosis. But this is accompanied with such inconveniences, that the operation is indicated under any circumstances from the physician's stand-point.

These rules apply to the organic pyloric stenosis caused by cicatrization. Provided we may assume merely a spasm, we will concede a larger place to the internal treatment; and even when a reason prevails to seek for the impediment in inflammatory infiltration of the wall, all phenomena of retention may disappear under internal treatment,—to be sure, in most cases not permanently.

The indication for operation is naturally the same, whether the impediment is caused by a mediogastric stenosis, a pyloric constriction or by the cicatrization of a duodenal ulcer. Only the interference will be an entirely different one. At the mediogastric stenosis we will, if possible, remove the impediment by a transverse resection, or unite the upper sac with the lower one or with the jejunum. At the pyloric constriction we will, as a rule, be satisfied with the gastro-enterostomy, and at the duodenal stenosis we have to decide according to the prevailing circumstances, whether we will undertake the simple gastro-enterostomy, or the one-sided disconnection of the duodenum, or even its resection.

4. If the Röntgen examination shows us the clear picture of a penetrating ulcer in the region of the lesser curvature, the indication for operation must depend upon the judgment of the surgeon. *Which* operation is to be chosen, gastro-enterostomy alone, or excision of the ulcer or transverse resection,—does not depend upon the Röntgen picture, but upon the attitude of the surgeon toward the question of resection. Only in one direction may the Röntgen picture point the way: when Haudek's notch is very wide, we must conclude, that the operative interference will be a very extensive and difficult one. In cases of a large notch, even when we are, on the whole, believers in excision of the ulcer or of the transverse resection, we must, from the beginning, proceed cautiously if the patient gives us the impression of inability to stand severe interference, or if his subjective complaints would not justify a severe interference not entirely without danger. Finally, an ulcer situated high up on the lesser curvature lends itself less to excision, but gives, on the other hand, success after gastro-enterostomy, than a notch ulcer situated nearer the pylorus.

5. A positive condition within the duodenum—duodenal spot, abnormal form of the cap, unusual filling and abnormal form and direction in the course, and abnormally small displacement of the other part of the duodenum—gives us in connection with clinical symptoms, a more or less decided indication for operation and, at the same time, points to the nature of the interference. The choice is here, too, not caused by the examination findings, but by the attitude and experience of the surgeon.

V. What advantages do Röntgen diagnostics offer for judgment as to the immediate and subsequent results of operation?

In recent years we have become more confident on matters relating to the surgery of the stomach and intestine, not the least because we are able to judge and control more safely than previously the consequences to the patient *after* operation, and because we are therefore able to

remove eventual disorders and follow our aim more consistently than formerly.

A. The Immediate Effects of Operation.—Although severe derangements of the evacuation of the stomach in cases of simple gastro-enterostomies have now become rare, owing to progress in technic, they have not entirely disappeared even in benign affections of the stomach. Ptosis, motor insufficiency of the stomach (very rare), old adhesions may even now originate after interferences which have been apparently correctly executed. We must be particularly cautious, when there are complicated conditions in consequence of former operations which have been followed by a new ulcus ventriculi or an ulcus pepticum jejuni. When a gastro-enterostomy will not suffice, the question confronting the surgeon will be a double one: *Shall* another operation be performed, and if so, ***how*** shall it be done?

In reply to the first question, the Röntgen examination usually gives the correct answer. Provided nothing has passed out of the stomach after 6 hours, the need of an interference is very great, and provided the closure remained intact after 12 hours, in spite of change of the patient's position (especially right side, even knee-elbow position) an operation must be made.

When, on the contrary, we find the intestine already partially filled after this period in spite of a large gastric residue, we may comfortably wait, for the impediment will probably be removed by itself.

But especially important is the explanation which the Röntgen picture affords relative to the seat of the impediment. When not only the stomach, but also the upper duodenal peduncle is filled, we are concerned with a regular vicious circle which will be remedied by Braun's anastomosis. But when the two loop peduncles applied to the stomach are empty, the anastomosis is of no value, and it must be cared for in a manner so that the newly created opening, between the stomach and the intestine, functions, or that in evading the existing one a new gastro-enterostomy is applied, for example, by means of a far-reaching Y. Elsewhere I observed a case in which the omission of the Röntgen control led the operating surgeon to an incorrect and unsuccessful after-operation. This case clearly showed what little reliance can be placed upon the supposition, that we can normally judge the conditions at the after-operation and select the right interference. The Röntgen picture usually permits a much more reliable judgment of the function than the "immediate glance," so often disturbed by adhesions.

The Röntgen picture gives also trustworthy explanation with refer-

ence to the operative effects at the excisions of ulcers and at the transverse resections.

As I have already shown in 1911, circumscribed spasms in the region of the suture line may appear long after the operation itself, which spasms may be dispelled by atropine. These usually do not impair the gastric functions. Since then we have further observed the continuous spasm in the region of suture lines involving the stomach, as, for instance, in a case of papillomatous polypi of the mucous membrane, for which the excision of the gastric wall involved only the mucous membrane and the submucosa, whereas the muscular layer was sewed without resection. Stierlin has, on the other hand, shown, based upon our clinical experiences, that the pylorospasm disappears after the transverse resection, which we so frequently observe in ulcers of the lesser curvature. Following immediately upon the operation of transverse resection, obstructions in the *upper* part of the stomach may arise, which are to be referred not only to the local spasm, but probably to a light, post-operative infiltration of the gastric wall in the region of the suture, and to a preceding kinking of the surface. I saw a disturbance of the gastric evacuation for the first two weeks which was very unfavorable, but which proved, upon repeated Röntgen examinations, not to be complete, so that we could wait patiently. The function of the stomach which had been subjected to a transverse resection was restored to a normal condition. Our observations as to transverse resection of the stomach are now affirmed by Kümmell, and especially so in regard to the light spastic congestion above the suture, and in regard to the unusually rapid evacuation of the lower section of the stomach, described by Stierlin. Kümmell, too, found that the entire function of the stomach is not at all impaired by the light congestion above the suture line, and that, on the contrary, the evacuation of the stomach occurs quicker than under normal conditions, an observation which Küster could, however, not verify. This brings us to the final results upon an operated stomach.

B. The Diagnostic Criticism of the Ultimate Disturbances and Final Results.—It is very valuable to be able to control the further development of our gastro-intestinal operation with the aid of the Röntgen examination. Let us begin with the functional disorders.

Mikulicz has already emphasized the fact, that after a gastro-enterostomy, successful from the very outset, a favorable course does not always follow, and that in some cases the result may be complicated more or less by pronounced late disturbances; and this statement has been reiterated in the past years by Clairmont, Deaver, Dénécheau and

others. Every operating surgeon who pays attention to these things in his later examinations will be able to report such cases. In this way it is of especial value to be capable, with the aid of the Röntgen picture, to perceive, at least to a certain degree, upon what the late disturbances depend. We may best divide them in accordance with our experience in two groups:

1. *Late disturbances without interruption in the progress of food, i.e.,* with evacuation of the stomach within the first 4 to, at most, 6 hours with normal peristalsis. Here there is no mechanical impediment, for even with good compensation such would manifest itself through abnormally deep peristaltic waves. The disturbances depend either on the continuance of the old ulcer or on the formation of a new one in the stomach or jejunum; or at last they belong to the favored chapter of adhesion pains behind which there is too often simply a delicate nervous system.

The continuance or new formation of an ulcer can sometimes be seen in the Röntgen picture without further investigation. Thus, I found a well developed ulcer notch explaining the severe complaints of a woman formerly subjected to gastro-enterostomy by another surgeon, because of an ulcer. A new interference showed that there really existed a penetrating ulcer. It might very readily have been of later origin, for in its region, near the lesser curvature, 3 other scars of old ulcers were found. The ulcer was extirpated, as the circumstances did not indicate a transverse resection. The complaints lessened considerably without entirely disappearing. A re-examination, 1½ years subsequently, again showed the existence of a small notch. In other cases, especially where the duodenum is involved, the Röntgen picture renders no aid, and we learn of the continuance of the ulcer only through the pains and the re-occurrence of hemorrhages. In two cases of ulcus duodeni treated by other surgeons by inturning and in which the motility was normal according to the Röntgen picture, I had to resort to the one-sided disconnection of the pylorus, when the troubles continued with renewed hemorrhages.

In cases of secondary disorders as well as in consequence of peptic ulcers of the jejunum the Röntgen picture affords no criteria. We can make the diagnosis as a conjecture only from the intensity of the complaints, and from the fact that there had been an anterior gastro-enterostomy with long jejunal leg.

As to the disturbances due to adhesions, it is conceivable that adhesions between stomach or jejunum and anterior abdominal wall will lead to complaints, even when the passing of food is not immediately

disturbed. Adhesions of this kind could possibly be detected in a profile view. Much more frequently the adhesions do not involve the abdominal wall, but are limited to the region of the actual site of operation, *i.e.,* the gastro-intestinal sutures, and here they will not, we believe, lead to grave complaints with normal individuals. Usually it is more the nervous system that is to be suspected. A man twenty years old, the diagnosis in whose case was stenosed pyloric and duodenal ulcer, had undergone somewhere else an operation of gastro-enterostomy. He now asserts that his complaints remain the same or even increased. The Röntgen picture shows that along with the well functioning gastro-enterostomy there is also a fully functioning pylorus; therefore no stenosed ulcer. Blood in the fæces not to be found, in spite of repeated examinations. Evacuation of the stomach is entirely normal. In consequence of his intense complaints, preventing, as he stated, every professional work, and at his urgent request, an inspection of the abdomen is made. The result is, absolutely normal conditions existing in the region of the gastro-enterostomy, a normal pylorus and normal duodenum with no sign of an ulcer still present, and without the least trace of cicatrization or thickening; pylorus normally permeable; no adhesions between stomach or intestine and anterior abdominal wall. The course of healing is normal in every particular, and his complaints disappear. The question immediately arises: did both the pyloric and duodenal ulcers, which were found at the first operation, disappear without scars or was the surgeon who in the first instance performed the operation, mislead by the well known white spot—the appearance of a particle of the muscular layer during a spastic contraction—or by a pylorospasm present during the operation? We will not decide the question. But the case is instructive and shows the importance of the secondary complaints in cases of gastro-enterostomy.

Such secondary complaints by a patient may be attributed to cases in which an ulcer, benign at first, develops into a carcinomatous one, or in cases where carcinoma, overlooked at the first operation, continues to develop. In such cases, too, the Röntgen picture gives no definite aid in the beginning. In time, however, a defect in the filling will occur which cannot be explained by the mere existence of a gastro-enterostomy.

2. *Late Disturbances Accompanied with a Retardation in the Passing of Food.*—Such late disturbances may be due to different causes:

Cases in which the gastro-enterostomy was done at an unsuitable place, or, as was formerly the custom, cases in which it was made too

small, yet could, to be sure, function for some time and facilitate the healing of the ulcer. Along with this the pylorus would again function, and the artificial gastro-intestinal opening would necessarily contract. In case a second pylorospasm sets in in consequence of a new ulcer, the gastro-enterostomy no longer suffices, and the result is a more or less pronounced degree of retention, a 6 hours' residue, etc.

Where the original operation was not gastro-enterostomy, but excision or transverse resection, at which an abounding fortifying of the suture by means of the omentum was done, this omental cord along the suture may cause the development of a gastric constriction gradually tightening with positive retardation of passage of the food. On one occasion I observed this after elliptic resection, and on another after an abounding fortifying of the suture of an acutely perforated ulcer of the lesser curvature. In both cases the omental cord was responsible for the signs of retention which appeared several months later. The Röntgen picture showed the gastric shadow sharply cut at the height of the cord.

3. Especially important is the after-examination with X-rays in making the comparative judgment of the different principles and methods of operation. The different methods of gastro-enterostomy may be examined, as Hartmann particularly did, with regard to their function and the lack of secondary complaints. Furthermore, the methods of resection may be compared, particularly the elliptic excisions and the transverse resection for the ulcer at the lesser curvature. Then the results of the excision of ulcer for the ulcers of the lesser curvature may be compared with the results of the mere gastro-enterostomy. In a similar way for the duodenal ulcer, the results of the mere gastro-enterostomy ought to be compared with those of the simultaneous pyloric disconnection and, finally, the different methods of disconnection should be comparatively studied.

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